GUJARAT MINERAL DEVELOPMENT CORPORATION LTD
(A Govt. of Gujarat Enterprise)

T. No- 1/ LP/ REPAIR, RETROFITTING & WATER PROOFING WORKS / COLONY QUARTERS / 2025 (Re invite)

Work of Repair, Retrofitting and water proofing works of Colony quarters located at SKV Nagar, Panandhro, GMDC lignite Project Panandhro, Tal: Lakhpat , Dist- Kutchh.

TECHNICAL BID-IV

TECHNICAL SPECIFICATIONS FOR ALL ITEM

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SPECIFICATIONS FOR STRUCTURAL REPAIR WORK

GENERAL

Quality Assurance

Submittals:

The contractor shall submit manufacturer's certification that the firm has manufactured the supplied materials.

1.1.1.1 Labelling:

All containers shall be clearly marked with following information.

(a) Name ofManufacturer
(b) Manufacturer's product identification
(c) Manufacturer's instruction for mixing.
(d) Warning for handling and toxicity.
(e) Date of manufacturing & its shelf life.

1.1.1.2 Manufacturer's Test Certificate:

The contractor shall submit manufacturer's certification verifying conformance to material specification as specified.

1.1.1.3 Application control:

The contractor shall submit mixing application procedure for each of the manufactured repair material for the approval of Engineer-in-Charge prior to their use.

1.1.1.4 Measurements Control: Measurements for payment of the item of repair shall be done only after completion of all steps of execution listed in the particular specification.

1.1.2 Product Delivery, Storage and Handling:

Storage: The contractor shall get approved from the Engineer-in-Charge the storage space for epoxy/polymer/patented/other manufacture of materials to ensure that the storage temperature is maintained between 5^0 C and 38^0 C unless recommended otherwise by the manufacturer.

Delivery: Contractor shall deliver all materials in sealed containers in packing as approved by Engineer-in-Charge with labels legible and intact.

Handling: All materials shall be handled in a safe manner and in a way to avoid breaking container seals.

1.1.3 Environmental Requirements:

Contractor shall comply with manufacturer recommendations so as to comply with environmental conditions under which the repair materials may be applied.

1.1.4 Personnel:

1.1.4.1 General Requirements

(1) Production, processing, testing and supervision require the employment of an Engineer-in-Charge by the Employer and Site Contract Manager & skilled site workers by the contractors who shall have adequate qualifications and experience for the proper execution of such works and already performed works of this kind with success.

1.1.4.2 Engineer-in-Charge:

(1) The Engineer-in-Charge shall represent the Employer and should have adequate knowledge and experience in protection and repair measures for the work.

(2) The Engineer-in-Charge is in charge of and responsible for work on the construction site and where relevant, for the management of the Materials Field Testing Laboratory. He may perform the tasks of the competent planning engineer

(3) So far as they have not been dealt with at the planning stage, the tasks of the Engineer-in-Charge include:

- Recording and evaluating the states of structures, for example in terms of statics, design, concrete technology, materials technology, fire protection technology and physics relating to construction (determination of the actual state and of the causes of damage).
- Deciding whether additional experts should be consulted in respect to safety, relevant work and other specialized tasks.
- Assessing protection and repair plans especially in respect of the choice of the repair systems to be employed.
- Planning and assessing application oriented suitability tests.
- Setting out and, where relevant, assessing performance specifications and assessing the feasibility, effectiveness and durability of the protection and repair measures, taking structural stability aspects into account.
- Devising working plans.
- Assessing the specialist qualifications of the skilled site personnel and test laboratory personnel
- Evaluating internal supervision measures.

1.1.4.3 Site Contract Manager

(1) The site contract manager or a qualified deputy of the site contract manager is the engineer representing the contractor, whose credentials were submitted and approved by the employer before issue of tender forms. He must be present on the construction site at all times during construction works.

(2) The site contract manager ensures safe execution of the works according to the plans and, in particular, discharges the following tasks over and above his tasks.

a) Notifying the works to the employer and the consultant
b) Arranging for and carrying out supervision
c) Using the envisaged, (quality) assured construction materials.
d) Where relevant, ensuring adequate treatment of the concrete substrate and intermediate layers.
e) Ensuring compliance with the technical conditions for the works and with proper production, processing, after-treatment, and formwork removal as stipulated by the Engineer-in-Charge or the consultant.
f) Communicating the most important results of internal supervision measures to the external supervising authority.
g) Supervision measures in respect to preventive safety engineering and occupational medicine.

1.1.4.4 Skilled Site Personnel

(1) Skilled workers shall be employed by the Contractor. They shall be equipped with special training in manual crafts and possessing knowledge, skills and practical experience in respect of concrete technology and other materials appropriate to the scope, type and difficulty of the repair measures. They must be present on each construction site at all times. His qualification for works according to these guidelines must be demonstrated to the external supervision agency by means of an appropriate certificate.

(2) The Contractor must ensure that the skilled workers employed at site, are informed of and instructed in protection and repair measures at maximum intervals of 3 years so as to enable them to take all measures for the proper execution of the construction measure, including tests and internal supervision as per the latest prevalent technology.

(3) The tasks of the skilled site personnel include

- practical execution of the protection and repair measures according to the prescribed planning / execution documents (directions for execution).
- specifying and supervision any work delegated to other skilled site personnel, insofar as it affects the success of the measure.
- directing the other skilled site workers to whom execution of the construction measures has been entrusted and checking their manual craft skills.
- carrying out the tests required as part of internal supervision and recording and interpreting the results.

(4) If the Contractor has a Materials Field Testing Laboratory (see Section 1.0.7) with appropriately qualified personnel the requirements contained in Paragraphs (1) and (2) in respect to the skilled site personnel are deemed to be satisfied if

- responsibility for the tasks is assumed by the Materials Field Testing Laboratory and
- a person delegated by the Materials Field Testing Laboratory is present on the construction site at all times and
- This delegated persons has been instructed and trained in the relevant protection and repair measure and the results of the training have been documented to the external supervising authority.

1.0.5 Safety:

Workers: Contractor shall advise all workers working with epoxies to avoid contact with eyes and skin, inhalation of vapours, and ingestion. Necessary protective and safety equipment's in the form of hand gloves, welders' goggles, shall be provided by the contractor and used on site.

Structural Safety: Care shall be taken to ensure that vibrations are well within acceptable limits for structural safety and users of the building.

1.0.6 Tools & Plants (T&P):

(1) For the execution of protection and repair works, properly maintained plant and equipment permitting adequate treatment of the concrete substrate, proper execution of the work and determination of the required properties of the construction materials and construction measures must be present on the construction site.

In particular, these are plant and equipment for

a) Treatment of the concrete substrate
b) Dosing of the base materials.
c) Mixing of the base materials
d) Processing and after-treatment
e) Measurement and testing.

(2) To ensure efficient and effective functioning, all plant and equipment must be checked on-site and at field material testing laboratory prior to first use and at appropriate intervals thereafter.

1.0.7 Materials Field Testing Laboratory:

(1) The Materials Field Testing Laboratory must be equipped and staffed to carry out all pre and post repair tests (*Refer Appendix 1.1-Test Methods for* Execution of Works) to ensure required quality of repair jobs and also to monitor the satisfactory performance of plant and equipment during execution. The testing laboratory and the site must cooperate closely with one another.

(2) The materials testing laboratory carries out the following specific tasks:

a) Suitability testing for concrete and shotcrete; assessment and choice of premixed construction materials.

b) Assessing and, where necessary, testing the concrete substrate and intermediate layers.

c) Checking and supervision of the required technical conditions.

d) Testing quality and setting, in so far as such tests are not performed by the skilled site personnel.

e) Checking the equipment of the construction sites according to Section 9.0.6 above prior to commencement of the works.

f) Continuous checking and advice in respect to the production, processing and after-treatment of the construction materials. The results of checks according to e) and f) are to be recorded.

g) Interpreting and assessing the results of site tests on all work sites advised by the materials testing laboratory and communicating the results to the Contractor and its site contract manager.
h) Training / refreshing the know-how of the skilled site personnel.

(3) The Contractor may not entrust internal supervision to a field materials testing laboratory also responsible for supervising one of its suppliers.

(4) The Materials Field Testing Laboratory may also cause the sites to be equipped with test devices.

This applies particularly to

i) testing of base materials
ii) testing of the concrete substrate
iii) testing processing conditions
iv) testing the construction materials in the green state and after setting.
v) Where necessary, checking layer adhesion.
vi) Making up and storing test specimens and retained specimens.

(5) Where necessary, the Materials Field Testing Laboratory must ensure that the site is equipped with the necessary plant and equipment for supervision measures and tests during the required period. Functioning of all plant and equipment at the Materials Field Testing Laboratory and on the construction site must be checked prior to first use and at appropriate intervals thereafter.

1.0.8 SUPERVISION OF WORKS

1.0.8.1 General

(1) Supervision consisting of internal and external supervision must be conducted for construction measures according to these guidelines.

(2) Internal supervision must be carried out by the site contract manager in conjunction with the specialized staff of the Contractor and possibly in conjunction with the field materials testing laboratory.

(3) External supervision must be carried out by a supervisory association or on the basis of a specified contract with an official testing institute.

(4) For construction measures according to these guidelines, the Contractor or the site contract manager must notify the following information to the external supervising authority at latest 48 hours before commencement of the relevant works.

a) designation of the construction site, qualified executive manager, site contract manager, skilled site personnel.
b) The existence of written directions for the site in respect to the production, processing, after-treatment and supervision of all tasks required.
c) The intended time of commencement and probable time of completion of the works.
d) The internal supervision laboratory.
e) If work is interrupted for a lengthy period – especially following lengthy periods of frost or, where relevant, rain – recommencement of the works must be notified.

1.0.8.2 Internal Supervision

Documentation during Execution of the Works

(1) Depending on the type and scope of the works, continuous verifiable records of all data significant for the quality and durability of the structure and its parts are to be made in a certifiable form, e.g. on forms (site log)., by the site contract manager, his deputy or the skilled site personnel for construction measures according to these guidelines. They must contain at least the following information

a) commencement and completion of the individual works.

b) Whether conditions, air temperature, atmospheric humidity (where relevant), temperature of the materials at the time of execution of the individual construction phases or components up to adequate hardening. A special note must be made of days on which the processing conditions were not fulfilled (e.g. due to frost, rain).

c) The materials processed

d) Supplier and delivery note, batch number where relevant

e) Records of the work procedures and checks according to the directions for work and execution.

f) Proper functioning of the equipment employed

g) Specimens made up, with their designations, date of making up and details of the individual components or phases of construction for which the associated construction material was used, test date and results and required properties.

h) Testing of the concrete substrate and, where relevant, of intermediate layers, with results specified for each component

i) Where necessary, temperatures and moisture of the components.

j) Measures taken when requirements were not met

k) Names of the skilled site personnel executing and supervision the work.

(2) The records must be available on the site during the construction period and must be shown on demand to the person responsible for supervision.

(3) Following completion of the construction works, the results of important tests stipulated by the external supervision agency must be handed over to that agency.

Type, Scope and Frequency of Supervisory Measures

(1) The type, scope and frequency of the supervision measures are specified in Tables 1.1 to 1.7; if the construction measure is interrupted, the test time spans are prolonged accordingly.

(2) In case of doubt, tests which are not normally required, for example on properties of the base materials, their composition, suitability of methods of execution and testing, must also be performed. The qualified executive manager is responsible for ordering such tests.

(3) If test results are inadequate, the Contractor must eliminate the causes and any defects – where necessary including defects on the structure – without delay.

Table 1.1: Concrete according to IS: 456 (continued)

Sl. No.	Object of test	Type of test, test on, test variable	Requirements	Frequency, time
	Base materials			
	Cement	Delivery note and packaging stamp or silo certificate (possibly lead-sealing)	Labelling (type, strength class and proof of monitoring) according to IS269 IS:3466	Each delivery
2.	Aggregate	Delivery note	Designation, proof of monitoring according to IS 383	Each delivery
3.		Visual inspection for aggregate type, granulometric composition absence of rock defects, harmful constituents (e.g. clay, chalk, coal) and particle shape	Compliance with specifications according to IS 383: 1952	Each delivery
4.		Granulometric composition Through sieve analysis according to IS 383	Compliance with granulometric composition and reproducibility	At first delivery, at appropriate intervals, on change of a manufacturing works
5.	Concrete agents, fibres, colorants	Delivery note and possibly sack labeling or silo lettering	Designation, mark of conformity or approval and proof of monitoring	Each delivery
6.	Concrete agents	Delivery note and packaging or drum labels or silo lettering labeling	Designation, mark of conformity and proof of monitoring	Each delivery
7.	Admixed water	Constituents interfering with initial setting and hardening	No constituents interfering with initial setting and hardening	Only if potable water is not used and if interfering constituents are suspected
	Prefabricated materials			
8.	Handover of ready mixed concrete and fresh mortar	Delivery note	Complete specification data according to IS 4926	Each delivery
9.	Handover of plant-mixed dry products	Delivery note and packaging stamp, labeling	Designation, proof of monitoring	Each delivery
10.		Visual inspection	No obvious changes	Continuously
11.	Storage	Storage conditions	According to manufacturer's directions for use	On storage, in case of doubt
12.	Working plan	Directions for treatment of the substrate	**Mean Tensile Strength** $\geq$1.5 N/sq mm; Min. & Max Temp as per Step-1 in 1.4.1.2	Prior to commencement of works

Sl. No.	Object of test	Type of test, test on, test variable	Requirements	Frequency, time
	Concrete substrate	Visual inspection	Suitability of concrete substrate for the planned measure	Prior to commencement of works
		Surface tensile strength	Suitability of the concrete substrate in terms of surface tensile strength according 3.2.1.4	> 20m² 3 single tests > 200m² 3 single tests per started 200m²
	Concrete			
	Composition of materials	Suitability tests based on IS: 456 attained reliably	The properties required in each case must be materials or site onditions	Prior to commencement works and if the base change significantly.
	Mixed materials	Composition of the mixture	Compliance with mixing directions	First use of each type; at appropriate intervals; during production of test specimens for strength tests
	Green concrete	Consistency (appearance)	Compliance with specified consistency range	Each mix or delivery vehicle
		Consistency factor according IS 1199: or as determined	Compliance with the consistency factor specified in the suitability test for	First use of each type; appropriate intervals; production of test specimens for strength tests
		Water content	Compliance with the specification	According to IS:456:2000
		Air content according to IS 1199	Proof of air content for concrete or mortar with high frost/salt resistance according to IS 456	First use of each type; at appropriate intervals (each mix)
	Hardened concrete	Compressive strength according to IS 516	Proof of compressive strength of concrete according to IS 456	Every 7 days during use of concrete/mortar, a series of six test specimens
		Impermeability to water according to IS 3085	Compliance with specification	By agreement, but at least three test specimens
23.	Working plan	Directions for making up (mixing directions), transportation, working and after treatment	Compliance with specifications	Prior to commencement of works
24.	Weather	Air temperature, maximum and minimum values	Compliance with specifications	Every working day, prior to commencement of works, in case of doubt
25.		Relative atmospheric humidity	Compliance with specifications	Every working day, prior to commencement of works, in case of doubt

Sl. No.	Object of test	Type of test, test on, test variable	Requirements	Frequency, time
26.	Concrete	Moisture	Compliance with substratespecifications	Prior to commencement of subsequent works, in case of doubt
27.		Temperature	Compliance withIn Specifications	In case of doubt
28.	Construction Material	Temperature Specifications	Compliance with	Every working day, in case of doubt
29.	Finished Component	Adhesive strength	Compliance with Specifications	By agreement with the client if not agreed, then at least half the tests for surface tensile strength
30.		Concrete cover	Compliance with specifications according to IS 456	As specified
	Technical equipment			
31.	Dosing equipment for cement	Visual inspection	Unexceptionable functioning	Weekly
32.	Aggregate, colouring agents, fibres, admixed water, plant-mixed materials.	Function check	Compliance with projected quantity to an accuracy of 3%	At commencement of works, thereafter monthly
33.	Dosing equipment for concrete additives	Function check	Compliance with projected quantity to an accuracy of 3%	At least once per working day
34.	Mixing machines transportation, charging and compacting machines	Function check	Unexceptionable functi-oning, in the case of mixing in ready-mixed concrete transporters adequate screw height	At commencement of works, thereafter at least monthly
35	Measuring testing and laboratory equipment	Function check accuracy	Adequate measuring intervals	On first use, at appropriate
36.	Own or hired vehicles with IS 456 agitating equip -ment or mixer vehicles for transporting concrete and mortar	Adequate instruction of driver by Test Station E	Compliance with specification per	On first use, then at appropriate intervals

Table 1.2: Shotcrete

Sl. No.	Object of test	Type of test, test on, test variable	Requirements	Frequency, time
	Base materials			
1.	Cement	Delivery note and packaging label or silo certificate (possibly lead-sealing)	Labelling (type, strength class and proof of monitoring) according to IS 269	Each delivery
2.	Concrete aggregate	Delivery note	Designation, proof of monitoring according to IS 383	Each delivery
3.	Concrete additives	Visual check of type of aggregate granulometric composition stone quality and harmful constituents (e.g. clay, chalk, lime, coal)	Compliance with specifications in IS 383	Each delivery
4.		Granulometric composition by sieve analysis according to IS 383	Compliance with granulometric composition and reproducibility	At first delivery, once each week of concreting
5.	Concrete agents	Delivery note and possibly packaging or drum label or silo lettering	Designation mark of conformity to IS:9103 or approval & proof of monitoring	Each delivery
6.		Delivery note and packaging or drum label or silo lettering and proof of monitoring	Designation, mark of conformity to IS:9103	Each delivery
7.		Visual inspection	No obvious changes	Continuously
8.	Storage of base materials	Storage conditions	According to manufacturer's directions	At storage, in case of doubt
9.	Admixed water	Constituents interfering with setting and hardening	No constituents interfering with setting and hardening	Only if potable water is not used and interfering contamination is suspected
	Pre-mixed materials			
11.	Ready-mixed concrete or fresh mortar	Delivery note	Completeness of specified data	Each delivery
	Plant-mixed dry Products	Delivery note and packaging stamp, labelling	Designation, proof of monitoring	Each delivery
12.	Plant-mixed dry products	Visual inspection	No obvious changes	Continuously
13		Shortage conditions	According to manufacturer's instructions (directions for use)	At storage, in case of doubt
	Ready-mixed material, Test level 1			
14.	Concrete	Suitability tests	The properties required in each case must be attained	Prior to commencement of works and if the base materials or site conditions change significantly.

Sl. No.	Object of test	Type of test, test on, test variable	Requirements	Frequency, time
15.	Job-mixed concrete	Composition of the mix	Compliance with mixing instructions	At the beginning of each day of concreting, during production of test specimens for Strength tests
16.	Ready-mixed material, dry spray method	Inherent moisture	Compliance with agreed inherent moisture	<100m³ or 500m² = 1 series, 100m³/500m² to 300m³/1500m² = 1 series per 100m³/500m², >300m³/1500m² = 1 series per 250m³/1250m²+ 1 series at commencement of concreting
17.	Ready-mixed material, wet method dry method with admixed water	Consistency	Compliance with consistency factor specified on the basis of the suitability test	
		Green concrete apparent specific density	Compliance with the green concrete apparent specific density specified on the basis of the suitability test	
	Compressive strength		Compliance with the compressive strength specified on the basis of the suitability test.	
Shotcrete, test level 2				
	Green concrete	Green concrete apparent specific density	Compliance with the green concrete apparent specific density specified on the bases of the suitability test.	<100m³ or 500m² = 1 series,100m³/500m² to 300m³/1500m=1series per 100m³/500m² >300m³/1500m² = 1 series /1250m² + 1 series at commencement of concreting
	Green concrete	Water content	Compliance with the water content specified on the basis of the suitability test.	
22		Granulometric composition < 0.25 mm	Compliance with the granulometric composition specified on the basis of the suitability test.	In case of doubt
	Hardened concrete	Apparent specific density (air dry at storage 20°C, 65% relative atmospheric humidity)	Compliance with the apparent specific density specified on the basis of the suitability test.	<100m³ or 500m² =1 series, 100m³/500m² to 300m³/1500m²= 1 series per 100m³/500m²,>300m³/1500m² = 1 series per 250m³/1250m² at commencement of concrete.
		Compressive strength	Compliance with the strength class specified on the basis of the suitability test	

Sl. No.	Object of test	Type of test, test on, test variable	Requirements	Frequency, time
		Impermeability to water	Compliance with the impermeability to water specified on the basis of the suitability test	Half the tests for compressive strength, at least three specimens
	Concrete substrate			
	Surface for coating	Directions for the treatment of the concrete substrate and, where relevant, placing of reinforcement	Compliance with specifications	Prior to commencement of works
		Visual inspection measure	Suitability for the planned	Prior to commencement of subsequent works
		Moisture	Suitability in terms of moisture for the planned measure	Prior to commencement of subsequent of works, in case of doubt.
		Temperature	Compliance with specifications	In case of doubt
		Surface tensile strength	Suitability for the planned measure	By agreement with the client; in the absence of an agreement: >20m² 3 single tests> 200 m² 3 single tests per started 200m². The single tests must be distributed uniformly throughout the area.
Processing				
31	Working instructions	Directions for making up (mixing instructions) transportations, working and after treatment	Compliance with specifications	Prior to commencement of works
32.	Weather	Air temperature, maximum and minimum value; weather condition	Compliance with specificatons	Every working day
33.	Construction	Temperature	Compliance with specificatons	Every working day in case of doubt
34.	Surface of shotcrete	After-treatment	Compliance with specificatons	Each stage of work
35.	Finished component	Layer thickness	Compliance with agreed layer cover	Each stage of work
36.		Percussion	No cavities	Each layer
37.		Adhesive strength	Compliance with specifications or according to repair concept	By agreement with client; in the absence of an agreement 5 values per started 250m²; at least 5 values per structure
38		Concrete cover	Compliance with specifications	In case of doubt

Sl. No.	Object of test	Type of test, test on, test variable	Requirements	Frequency, time
	Technical equipment			
39.	Dosing equipment for base materials	Visual inspection	Unexceptionable functioning	Weekly
40	Prefabricated materials	Function check	Compliance with projected quantities	At commencement of works, thereafter monthly.
41.	Mixer, shotcreting equipment	Function check		
42.			Unexceptionable functioning	At commencement of works, thereafter at least monthly
43.	Measuring and testing devices	Function Check	Adequate measuring accuracy	On first use, at appropriate intervals
	Where relevant, own or hired transport vehicles with agitation equipment or readymixed concrete and mortar transporters	Adequate instruction of drivers by Test Station	Compliance with requirements	On first use, then at appropriate intervals

Table 1.3: Polymer-modified cement mortar and concrete, cement mortar

Sl. No.	Object of test	Type of test, test on, test variable	Requirements	Frequency, time
Pre-fabricated materials				
	Handover of plant-mixed products	Delivery note and packaging stamp	Designation, proof of monitoring	Each delivery
		Visual inspection	No obvious changes	Continuously
	Storage	Storage conditions	According to directions for use	On storage, in case of doubt
	Concrete substrate			
	Working plan	Directions for treatment of the concrete substrate	Compliance with specifications	Prior to commencement of works
	Concrete substrate	Visual inspection	Suitability of the concrete substrate for planned measure	Prior to commencement of subsequent works
		Surface tensile strength	Suitability of the concrete substrate in terms of surface tensile strength	> 20m² single tests; >200 m² 3 single tests per started 200m²
	Mortar/concrete			
	Composition of construction materials	Basic test	The properties required in each case must be attained reliably	Prior to commencement of works
	Mixed materials	Compositions of the mix	Compliance with mixing instructions	At first use of each type; at appropriate intervals; when specimens are made up for strength tests
	Green mortar/ concrete	Consistency (appearance)	Compliance with specified consistency range	Each mix
		Air content	Proof of required air content	At first use of each type, at appropriate intervals
	Hardened mortar / concrete	Flexural tensile and compressive strength	Proof of strength	Every 6 days during working of concrete / mortar, a series of 3 specimens; at least one series of 3 specimens.
	Processing	Directions for making up (mixing instructions), transportation, working and after-treatment	Compliance with directions for use	Prior to commencement of works
	Weather	Air temperature, maximum and minimum values	Compliance with specifications	Every working day, prior to commencement of works in case of doubt.
		Relative atmospheric humidity/weather conditions	Compliance with specifications	Every working day , prior to commencement of work, incase of doubt.

Sl. No.	Object of test	Type of test, test on, test variable	Requirements	Frequency, time
15.	Concrete	Moisture	Compliance with specifications	Prior to substrate commence ment of subsequent works, in case of doubt.
16.		Temperature	Compliance with specifications	In case of doubt.
17.	Construction material	Temperature	Compliance with specifications	In case of doubt.
18.	Finished component	Adhesive strength	Compliance with specifications	By agreement with the client, in the absence of an agreement, at least half the tests for surface tensile strength
19.		Concrete cover	Compliance with specifications	By aggrement
	Technical equipment			
	Dosing equipment for additives and water.	Visual inspections	Unexceptionable functioning	Weekly
		Function Check	Compliance with projectedquantity to an accuracy of 3%	At commencement of works, thereafter monthly
	Mixing equipment, transportation, charging and compacting equipment	Function check	Unexceptionable functioning	At commencement of works, thereafter at least monthly.

Table 1.4: Epoxy mortar and concrete

Sl. No.	Object of test	Type of test, test on, test variable	Requirements	Frequency, time
Prefabricated materials				
1.	Handover of plant mixed products	Delivery note and packaging stamp	Designation, proof of monitoring	Each delivery
2.		Visual inspection	No obvious changes	Continuously
3.	Storage	Storage conditions	According to directions for use	On storage, in case of doubt
	Concrete substrate			
4.	Working plan	Directions for treatment of the concrete substrate	Compliance with specifications	Prior to commencement of works
5.	Concrete substrate	Visual inspection	Suitability of the concrete substrate for the planned measure	Prior to commencement of subsequent works
6.		Surface tensile strength	Suitability of the concrete substrate in terms of surface tensile strength	>20 m2 tests;>200 m2 3 single tests per s.
	Epoxy mortar/concrete			
7.	Composition	Basic test of construction materials	The properties specified in each case must be attained reliably	Prior to commencement of works.
8.	Mixed construction materials	Composition of mix	Compliance with mixing Instructions	On first use of each type; at appropriate intervals; when specimens are made up for strength tests.
9.	Green mortar/ concrete	Consistency (appearance)	Compliance with specified consistency range	Each mix
10.	Hardened mortar/ concrete	Flexural tensile and compressive strength according to Table 5.8	Proof of strengths according to specifications	Every 6 days during working of concrete / mortar, a series of 3 specimens; at least one series of 3 specimens.
	Processing			
11.	Working plan	Directions for making up (mixing instructions) transportation, working and after treatment.	Compliance with directions for use.	Prior to commencement of works.
12.	Weather	Air temperature, maximum and minimum value.	Compliance with specifications.	Each working day, before beginning work, in case of doubt.
13.	Weather	Relative atmospheric humidity, weather conditions	Compliance with specifications	Every working day, prior to commencement of works, in case of doubt.

Sl. No.	Object of test	Type of test, test on, test variable	Requirements	Frequency, time
14.	Concrete substrate	Moisture	Compliance with limits specified by material manufacturer	Prior to commencement of subsequent works, in case of doubt.
15.		Temperature	Temperature 3^{o} C higher than dew-point temperature	Prior to commencement of execution of the works and following changes in the weather.
16.	Construction material	Temperature	Compliance with specifications	Prior to commencement of execution of the works and following changes in the weather.
17.	Finished component	Adhesive Strength	Compliance with specifications	By agreement with the client; in the absence of an agreement, at least half the test for surface tensile strength.
	Technical Equipment			
18.	Dosing equipment	Visual inspection	Unexceptionable functioning	Weekly
19.		Function check	Compliance with projected quantity to an accuracy of 3%	At commencement of works, thereafter at least monthly.
20.	Mixing equipment, transportation, charging and compacting equipment	Function check	Unexceptionable functioning	At commencement of works, thereafter at least monthly.
21.	Measuring, testing and laboratory equipment	Function check	Adequate measuring accuracy	On first use, at appropriate intervals.

Table 1.5: Surface protection systems

Sl. No.	Object of test	Type of test, test on, test variable	Requirements	Frequency, time
	Base materials/ system			
	Surface protection System	Delivery note, packaging stamp	Designation proof of monitoring.	Each delivery.
		Visual inspection	No obvious changes	Continuously.
	Storage	Storage conditions	According to manufacturer's regulations	On storage, in case of doubt.
	Composition of materials, system	Basic test	Compliance with directions for use	Prior to commencement of works, at each change in materials, systems.
	Concrete Substrate			
	Working plan	Directions for treatment of the concrete substrate	Compliance with directions for use	Prior to commencement of works.
	Concrete substrate	Visual inspection	Suitability of concrete substrate for the planned measure	Prior to commencement of subsequent works.,
		Surface tensile strength	Suitability of concrete substrate	>20 m^2 3 single tests; > 200 m^2 3 single tests per started 200 m^2
	Processing			
	Working plan	Directions for making up and working	Compliance with directions for use	Prior to commencement of works
	Weather	Air temperature	Compliance with directions for use	3 x per working day.
		Relative atmospheric humidity	Compliance with directions for use.	3x per working day.
	Concrete substrate	Temperature	Compliance with directions for use	Prior to commencement of execution of works and following changes in weather.
12	.	Moisture	Compliance with directions for use	Prior to commencement of execution of works and following changes in weather.
13.		.Dew-point temperature	Temperature 3^{O} C higher than dew-point temperature.	Prior to commencement of execution of works and following changes in weather
	Surface protection system			
14.	Protective measure	Quantities of materials	Comparison of quantities	As specified
15		.Layer thickness	Compliance with directions for use	As specified.

Sl. No.	Object of test	Type of test, test on, test variable	Requirements	Frequency, time
16.	Protective measurements	Visual inspection, pores, blisters	Compliance with require	As specified.
17		Adhesive strength	Compliance with Specifications.	By agreement with the lient; in the absence of an agree ment at least half the tests for surface tensile strength.
18.		Water absorption, test method not yet specified	Compliance with directions for use.	As specified.
19.		Grid test	Compliance with directions for use	As specified.
20.		Roughness (peak – to – valley height)	Compliance with directions for use.	As specified
21.		Electrical leakage resistance	Compliance with directions for use	As specified
22.		Voids content, test method currently being validated	Compliance with directions for use	As specified
	Technical equipment			
23.	Dosing equipment	Visual inspection	Unexceptionable functioning	Weekly
24.		Function check	Compliance with projected quantity to an accuracy of 3%	On first use, thereafter at least monthly
25.	Mixing equipment	Function check	Unexceptionable functioning	On first use, thereafter at least monthly.
26.	Processing equipment	Function check	Unexceptionable functioning	On first use, thereafter at least monthly
27.	Measuring and test equipment	Function check	Adequate measuring accuracy	On first use, at appropriate intervals.

Table 1.6: Crack-Sealing

Sl. No.	Object of test	Type of test, test on, test variable	Requirements time	Frequency,
	Base material			
	Filler, cement, damming material, fitting nozzles	Delivery note and packaging stamp	Designation, proof of monitoring.	Each delivery
		Visual inspection	No obvious changes	Continuously
	Storage	Storage conditions	According to directions for use	On storage, in case of doubt.
	Composition	Basic test	Compliance with required properties	Prior to commencement of works
	Concrete substrate			
	Working plan	Directions for treatment of the concrete substrate and the cracks	Compliance with specifications according to directions for use.	Prior to commencement of works.
	Concrete substrate	Visual inspection	Suitability for the planned measure.	Prior to commencement of works.
		(Component) temperature	Compliance with directions for use	Prior to commencement of works.
		Crack-width / change in crack width	As specified	Prior to commencement of works.
		Moisture state of the cracks	As per specifications	Prior to commencement of works.
	Processing (damming materials, filler)			
	Working plan	Directions for making up and working	Compliance with directions for use	Prior to commencement of works.
	Weather conditions	Air temperature	Compliance with directions for use	Prior to commencement of works.
	Filling nozzles	Function check	Through-feed	Each crack
	Damming	Function check	Sealing	Each Crack
	Cement paste, constant viscosity	Marsh funnel Discharge time	As in basic test and directions for use	Each mix.
	Cement paste and injection equipment.	Sand column filling	No plunger, < 10 min to emergence of cement paste	Daily before beginning work and in case of doubt.
	Crack-filling	Visual inspection	Emergence of cement paste from next filling nozzle	Each crack
	Filling	Degree of filling	Completeness of filling	By agreement with the employer, in case of doubt.

Sl. No.	Object of test	Type of test, test on, test variable	Requirements	Frequency, time
	Technical equipment			
18.	Dosing equipment	Visual inspection	Unexceptionable functioning	Weekly
19.		Function check	Projected quantities to an accuracy of 3%	On first use, at appropriate intervals.
20.	Mixing equipment for damming material for filling compound	Function check appropriate intervals.	Unexceptionable functioning	On first use, at
21.	Filling device	Function check	Unexceptionable functioning	On first use at appropriate intervals.

Table : 1.7 Corrosion protection materials for reinforcement

Sl. No.	Object of test	Type of test, test on, test variable	Requirements	Frequency, time
	Base materials			
	Corrosion protective material	Delivery note and packaging stamp.	Designation, proof of monitoring	Each delivery
		Visual inspection	No obvious changes	Continuously
	Storage	Storage conditions doubt	According to directions for use	On storage, in case of
	Composition of the system	Basic test	Compliance with required properties	Prior to commencement of works.
	Reinforcement			
	Concrete substrate, reinforcement	Visual inspection	Suitability of the substrate	Prior to commencement of works.
		Temperature	Compliance with directions for use	3 x per working day
		Moisture	Compliance with directions for use	Prior to commencement of works.
		Dew-point temperature	Compliance with directions for use	In case of doubt.
	Processing			
	Working plan	Directions for making up and working.	Compliance with directions for use.	Prior to commencement of works.
	Weather	Air Temperature	Compliance with the specifications	Each working day.
		Relative atmospheric humidity	Compliance with specifications (e.g. < 70%)	Each working day.
	Finished corrosion protection	Layer density	Compliance with directions for use.,	As specified.
	Technical equipment			
13.	Dosing equipment	Visual inspection	Accuracy 3%	Weekly
14.	Mixing equipment	Function check	Unexceptionable functioning	At commencement of works, thereafter at least monthly.

(4) After the defect has been remedied, the relevant tests are to be repeated insofar as they are technically possible and are necessary in order to verify elimination of the defect.

(5) Materials which fail to comply with the requirements must be separated and marked as unsuitable.

(6) Working equipment which fails to comply with the requirements must not be used and must be marked as unsuitable.

1.0.8.3 External Supervision

External Supervision by Consultant/Employer

a. Commencement of External Supervision

(1) Prior to commencement of external supervision of works, being carried out by Contractor, the external supervising authority must establish whether the personnel and equipment are such that proper execution of the works may be anticipated (initial test).

(2) The Contractor must communicate to the external supervision agency in writing.

a) the name of the Engineer-in-Charge and any change in this post.
b) Where relevant, the internal Materials Field Testing Laboratory the name of the Engineer responsible and any change in this post.
c) Commencement of work on each construction site at which works according to these guidelines are carried out.
d) The name of the site contract manager and any change in this post.
e) The names of the skilled site personnel according to Section 1.0.4.4 and any changes in these posts.
f) The nature of the work to be carried out.
g) The construction materials intended for use in each construction measure.

b. Execution of External Supervision

(1) Each notified construction measure must normally be inspected at least once without advance notice. Construction measures of longer duration must be re-inspected at appropriate intervals. The frequency of the inspections is to be decided by the external supervising authority, with due regard to its responsibilities, and is to be in line with its conclusions and with the results of internal and external supervision. The reliability of internal supervision measures, the conclusions arrived at in the course of external supervision and the special requirements imposed on execution of the works and on the materials / material – systems are to be taken into account.

(2) No objection is to be made in the case of defects, including any defects on the structure, which are detected in the course of internal supervision measures but which are eliminated without delay.

(3) In the case of significant objections, a repeat inspection is to be made.

(4) The person responsible for carrying out the tests must examine the records of internal supervision measures according to Section 1.0.8.2. including.

a) the site log
b) the test records (test frequency and results) and the internal supervision documentation
c) the documentation relating to execution of the works and where relevant the performance specifications and the directions for work.
d) The proofs of suitability and supervision and the directions for use issued by the manufacturer of the material
e) The delivery notes
f) The mixing instructions in cases where materials are produced on site.
g) The records of function checks carried out on the plant and machinery employed

(5) The person responsible for carrying out the tests must as far as possible inspect the execution of the construction measures; during such inspections he may carry out the tests specified in these guidelines or cause them to be carried out.

The following items must normally be inspected:

a) the nature and storage of the construction materials
b) the nature of the machines and equipment employed and their functionality.
c) The execution of the works according to the specified working plans and directions for execution.
d) The suitability and level of instruction of the skilled site personnel.

(6) In case of doubt, the person responsible for carrying out the tests must perform additional checks; he is also entitled to take specimens and to cause them to be tested or to test existing retained specimens or to cause them to be checked.

Sampling

(1) The specimen is normally to be taken on the construction site by the person responsible for carrying out the tests, in accordance with statistical principles.

(2) A construction material identified as defective or a material identified as unsuitable by internal supervision measures is to be excluded from sampling only if such material has been separated and has been clearly marked as defective or unsuitable.

(3) The specimen is to be marked uniquely. The person responsible for making the tests must prepare a report on the taking of the specimen, must sign the report and must have it countersigned by the person supervising the construction site. The report must contain at least the following items:

a) Contractor and site
b) description of the material
c) number or amount of the specimens and their markings.
d) Time and date
e) signatures

Supervision Report

(1) The conclusions arrived at by the external supervising authority and its evaluation must be recorded in a supervision report. The report must contain at least the following items:

a) Contractor, site and internal supervision laboratory.
b) Brief description of the construction measure
c) Engineer-in-Charge, site contact manager and skilled site personnel.
d) Details of the materials and requirements.
e) Conclusions on the equipment employed
f) Conclusions on the type and execution of the construction measures performed.
g) Conclusions on internal supervision.
h) Appraisal of internal supervision
i) Where relevant, details of specimens taken
j) Results of tests carried out in the course of external supervision
k) Date of the inspection, signature and stamp of the person responsible for carrying out the tests.

(2) The supervision reports must be kept by the Contractor and by the external supervising authority for at least 5 years.

Site Markings

Construction sites supervised are to be marked at a clearly visible point, citing the designation and the external supervising authority according to Section 9.0.4.

1.0.9 Records

The results of the tests must be recorded and must be subjected to an appropriate degree of statistical analysis. The records must be kept for at least five years after completion of the tests or of the construction project.

1.1 SITE REQUIREMENTS

1.1.1 PROPPING & SUPPORTING STRUCTURAL MEMBERS

PURPOSE: *To provide relief in stress and strains of structural members, which are deteriorated, overstressed, required to be repaired or strengthened, by transfer of dead and live loads safely through an alternate system to the founding medium.*

1.1.1.1 General

a) In repairs and rehabilitation works, design of false work is essential for avoiding damage to the distressed structure.

b) This is one of the most important operations in carrying out rehabilitation of a distressed structure. The success of structural repair depends mostly on ensuring that the parent material and the repair material of the structure participate jointly in resisting the applied loads due to self-weight and superimposed loads. Therefore, the quantum of relief given to distressed structural member determines success of the repair in the structural member.

c) It is necessary that the self-load and imposed loads over the structural members being repaired are transferred to the false work and the adjoining existing structural members safely, taking in to account the capacity of such adjoining members and the false work. And thus, the structural member is relieved of strains and stresses before it actually receives the structural repairs.

d) Particular attention is to be given to the shear capacity of the existing beams receiving load through false work, as it may lead to sudden and permanent damage to the structure being repaired.

e) Standardised false work systems are preferred option. The design of false work is to follow the general principles for the design of a permanent structure and relevant codal provisions.

f) Design brief covering all important operating instructions to the field engineers has to be prepared meticulously describing all issues crucial for the successful repair process.

g) The specifications of formwork (Centering and shuttering) contained in Para 5.2 of CPWD specifications 1996 (Vol-II) shall otherwise generally apply except otherwise mentioned herein these specifications.

1.1.1.2 Design Brief

Following are the important points to be included in the design brief of false work.

a) The plan of the structure.
b) Design considerations clearly giving material properties of the false work.
c) Dead and Imposed loads (including horizontal loads) on the false work.
d) Type of foundation for false work and its capacity, including flooding possibility, if any.
e) Reserve strength of supporting parent members.
f) Drawing & Specifications of falsework complete with required instructions.
g) Adjustment arrangement at the time of repairs.
h) Sequence of fixing and removal of false work including safe load transfer
i) Sequence of repair and strengthening

1.1.1.3 Requirements of good false work

a) It shall be strong enough to withstand all the dead and live loads and forces caused by dismantling, chipping, ramming, vibration of concrete and other incidental loads imposed over it including that of working platform and personnel during and after repair work.

b) It shall be made sufficiently rigid by using adequate number of ties and braces, screw jacks or hard wood wedges wherever required to ensure actual relieving of the load from member and its transfer through props, supports and structurally sound structural members of the existing structure.

c) Sole plates are secured and fixed against movement, forming level, camber as specified, if any.

d) Necessary plates, screw jacks, hard wood wedges shall be provided wherever required to make up any settlement in the props/supports.

e) Ladders, platforms, guardrails for providing access to the workmen are secured with the other members.

f) De-shuttering shall be done after the elapse of specified time and re-propping done if

specified. The manner of de-shuttering shall avoid instability during removal of false work.

1.1.1.4 Inspection of False Work

Following are the checkpoints before allowing the next stage of false work to proceed:

a) The compliance of notes given in the false work drawing and the specification of materials to be used in the work.
b) Setting out of the work, founding medium for support and sole plates of the props.
c) Sequence of erection keeping the stability of the false work in mind at every stage by ensuring proper connection of joints. It must be ensured that ties and /or bracing (longitudinal, lateral and inclined) have been joined near the nodes simultaneously to ensure stability of the false work.
d) The plumb of vertical members to be ensured within specified limit.
e) The false work executed shall conform to the approved design.
f) Centering and shuttering is properly serviced after removal and before its next use.

1.1.1.5 Execution Procedure:

Step-1 **Design the prop and support system** using steel tubular sections with extension pieces or with built-up sections to ensure required relief to structural members from stresses due to loads coming over it, including the self-load of the member itself. No timber ballies etc. shall be used as props. However, timber runners/beams/planks of adequate section could be used for supporting structural beams, slabs as load distribution mechanism.

Step-2 **Prepare the design brief** covering all-important operating instructions and shall be got approved from the Engineer-in-charge beforehand.

Step-3 **Arrange all propping and supporting elements** as per approved design.

Steps-4&5 Refer these steps separately **for columns, beams and slabs** as given subsequently.

Step-6 **Work shall be inspected before taking up structural repairs** for safe load transfer to the founding medium by implementation of approved drawings/design of prop & support system.

a) Steps 4 & 5 for Columns:

Step-4 **Identify and mark the RCC columns** under structural distress, which are unable to sustain service load conditions and/or which are required to be ripped open for undertaking structural repairs or retrofitting.

Step-5 **Prop and support the column for the full height** of building, to relieve its axial loads through its adjoining intersecting beams and/or slabs at all floor levels of the building using designed steel props adjustable with extension pieces, screw jacks etc with sole plates. This shall be done, even if only one storey length (intermediate, lowest or the uppermost storey) out of many storey lengths of the same column, had been identified for structural repairs.

The loads relieved are required to be transferred directly through props and supports on to the building foundation system or to soil as per approved design of foundations.

Under no circumstances, the column loads above the storey should be transferred by transfer through adjoining upper or lower intersecting beams alone.

b) Steps 4 & 5 for Beams:

Step-4 **Identify and mark the RCC beams** under structural distress, which are unable to sustain the service load conditions and/or are required to be ripped open for undertaking structural repairs or retrofitting.

Step-5 **Prop and support the identified beams** to provide relief in stresses & strains to the distressed beam by suitably supporting such RCC slabs, which are contributing load to the beam itself. The load relieving shall be done using designed steel props adjustable with extension pieces, screw jacks, hard wood wedges etc with sole plates at suitable intervals but shall generally not exceed 1.5 metre centre to centre as per design approved by Engineer-in-Charge.

To avoid any overstressing of any existing flexural members receiving the transferred load of the distressed beam, the steel prop and supports shall be taken and continued to the firm ground. For upper storeys, the steel props shall be taken at least two storeys below or as per the design approved by Engineer-in-Charge.

c) Steps 4 & 5 for Slabs:

Step-4 **Identify and mark the points for propping and supporting** on soffit of RCC slab requiring structural repairs, for transfer of loads to relieve it from stresses and simultaneously avoiding its collapse during the repair process. However, such points shall preferably be not be farther than 1.2m x 1.2m.

Step-5 **Prop and support slabs** at identified locations with steel props to provide relief in stresses & strains suitably as per approved design with bearing plates adjustable with extension pieces, screw jacks etc.

To avoid any overstressing of existing flexural members receiving the load of the distressed RCC slab, the steel props and supports shall be provided just below the aforesaid identified points and shall be taken and continued to the firm ground or at least two slabs below as per the design approved by Engineer-in-Charge.

1.1.1.6 Measurements:

Number of props of specified capacity shall be measured for the purpose of payment.

1.1.1.7 Rates:

The rates shall cover cost of all materials, labour and T&P involved in all the operations described above including its removal after the work duration. The removed material shall remain the property of the contractor.

1.1.2 SPECIAL WATERTIGHT SHUTTERING/FORMWORK:

PURPOSE: *To provide shuttering or formwork and its joints to be able to resist a*

hydraulic pressure at least equivalent to a 10 metres water head without causing any leakage.

1.1.2.1 General

Special watertight shuttering/formwork shall be provided for special applications involving concrete or mortar, which are more fluid than normal concrete. e.g. Preplaced Aggregate Concrete, Self compacting & self levelling concrete (pumpable concrete, Micro concrete, etc making use of plasticisers/ super plasticisers), etc. This shall necessarily require structural stability, retention of form shape and resistance to leakage under hydraulic pressures of water/cement slurry/ concrete/mortar not less than 10 metre water head. The hydraulic pressures could either be externally applied or due to static pressure of poured concrete or mortar.

1.1.2.2 Materials:

The basic material for shuttering /formwork shall be MS sheet and MS structural sections, fasteners and the joint sealants

1.1.2.3 Design:

The shuttering/formwork shall be suitably designed to be able to resist the assessed hydraulic pressures likely to be exerted.

Minimum Configuration of the shuttering plates shall however be as under:

a. Steel plate shuttering materials using a minimum 3 mm thick MS sheets welded over a frame of MS Angle iron or T-iron of minimum size 40 X 40 X 5 mm thick with shorter span not exceeding 600 mm.

b. 10 mm dia MS nuts, bolts and washers at a spacing of 300 mm c/c for connecting and tightening joints with suitable resilient packing material to ensure retention of required shape and water tightness for the required pressure.

1.1.2.4 Testing:

The sample of shuttering shall be tested for retention of its shape and water tightness before proceeding with the work

1.1.2.5 Fabrication and Erection:

The CPWD specifications for formwork, propping, centering and shuttering shall generally apply to fabrication and erection.

1.1.2.6 Measurement:

Wherever, water tight shuttering specified and stipulated to be paid for separately, measurement shall be taken of the area of shuttering in contact with the finished concrete/ mortar surface. Dimensions of the formwork shall be measured correct to a centimeter and area worked out in square metres correct to second place of decimal.

1.1.2.7 Rates:

The rates shall cover cost of all materials, labour and T&P involved in all the operations

described above including its removal after the work duration. The removed material shall remain the property of the contractor.

1.1.3 ENGINEERED STEEL TUBULAR DOUBLE SCAFFOLDING SYSTEM :

PURPOSE: *To prov ide a scaffolding system with adjustable working platforms on the exterior of the building for the workmen to work upon any part of the area to be accessed safely and with ease for surface preparation, application of repairs and construction activity.*

1.1.3.1 Materials:

The standard proprietary tubular double scaffolding system of repute with all accessories, working platforms etc

1.1.3.2 Design:

It shall be designed for all the incidental dead, live and wind loads as per IS: 875 in steel tubular sections as per general design considerations governed by IS:800. The design of the scaffolding system shall cater to the safety features for the workmen.

1.1.3.3 Fabrication and Erection:

Fabrication and erection shall be done as per the design brief and installation instructions of the proprietary firm. It shall be maintained in functional condition for the work duration.

1.1.3.4 Measurements:

For the purpose of payments, length and height of double scaffolding on the exterior of building shall be measured correct to a centimeter and area worked out in square metres correct up to second place of decimal. For internal work, suitable fixed or mobile platform, self supporting scaffolding with working platforms shall be erected for which no payment shall be made.

1.1.3.5 Rates:

The rates shall cover cost of all materials, labour and T&P involved in all the operations described above including its removal after the work duration. The removed material shall remain the property of the contractor.

1.1.4 PLYWOOD COVERING PANELS TO COVER WINDOWS ETC. DURING REPAIRS:

PURPOSE: *To protect the finished items against their spoiling/damage to finishes during the process of carrying out repairs in a building. The items could include finished windows, doors, glass curtain wall or other such items.*

1.1.4.1 Materials:

a) Wooden Battens of size 50mm X 50mm (approximately) or as approved by Engineer-

in-charge, free from warping, cracks etc. made from locally available timber.

b) Plywood of suitable thickness, preferably 6 mm thick, as approved by Engineer-in-Charge.

c) Nails, screws etc. as per requirement.

1.1.4.2 Fabrication

a) Size of covering panels shall be more than the size of windows etc. to be shielded/ protected, enough to be fixed to the walls without damaging the windows etc.

b) Wooden battens shall be cut approximately to the size of panels of windows etc. to be protected. The joints of the wooden framework shall be lap joint or as approved by Engineer-in-Charge.

c) Where the panel size is more than 2 square metres or as specified by the Engineer-in-Charge, the stiffening shall be done with batten backing to impart stiffness enough to provide rigidity against undue deflection due to impact of falling debris, self load, etc.

d) Plywood shall be fixed with nails/screws over the batten frames. The spacing of nails/screws shall be about 300mm c/c or as may be required at site.

1.1.4.3 Fixing

The plywood covering panel shall be suitably fixed without damaging the windows etc. being protected by such panels with nails/screws fixed in walls strong enough to resist the forces likely to be imparted during repair work. It shall be done in such a manner that it can be removed with ease without damaging the covered windows etc. after completion of repairs.

1.1.4.4 Removal

After completion of work, the covering panels shall be removed carefully, so as not to cause any damage to windows etc. covered. The damages, if any, shall be made good.

1.1.4.5 Measurements

The measurements shall be done correct to a centimeter for the dimensions of window etc. shielded /protected and area shall be worked out in square metre correct to second place of decimal.

1.1.4.6 Rates

The rates shall cover cost of all materials, labour and T&P involved in all the operations described above including its removal after the work duration and making good the damage, if any, caused to windows etc. so protected. The removed material shall remain the property of the contractor.

1.15 TEMPORARY BARRICADING USING ANGLE IRON VERTICALS AND CGI SHEETS PANELS:

PURPOSE: *To provide a barricading on ground to physically define the boundaries of the site of construction/repair activity for restricted entry of only those involved with the construction work.*

1.1.5.1 Materials:

Available Corrugated G.I. Sheet minimum 24 G thick, Framing structural material

(at least MS Angle iron of size 40x40x5mm or equivalent)

1.1.5.2 Fabrication & Erection:

a) Size of framing panel shall be decided depending upon site conditions and these could be approximately 2.0 metres long with height as 1.8 metre.

b) It shall be made up at least of two verticals, each with additional length of about 600 mm for fixing in to ground firmly and two horizontals equal to the length of panel.

c) It shall be made up by cutting the structural sections to size, shear punching holes in verticals and horizontals for nuts and bolts or making other suitable provision for receiving CGI sheet or other specified panelling material and connection of panel with adjoining panels.

d) Fabrication of frame of an individual panel shall be by welding at corners, welding MS plate at base of verticals or any other acceptable practice approved by Engineer-in-charge.

e) G. I sheet or other specified panelling material shall be suitably fixed. It shall preferably be done by means of nuts and bolts at its ends spaced at about 300 mm c/c transversely and at about 600 c/c longitudinally along corrugations. The corrugations of CGI sheet shall run along the shorter span of the panel.

f) In case of newly fabricated panels, these shall be painted with red oxide zinc chromate primer on steel work and approved primer on other material and at least one coat of paint of approved shade. In case of used panels, one coat of paint of approved shade shall be applied over the existing paint. The portion of verticals to be embedded in ground shall be suitably protected against rusting by painting it with bitumen or other suitable paint.

g) The fabricated panels shall be suitably fixed vertically and firmly in to the ground to the satisfaction of Engineer-in charge by maintaining a uniform height of about 1.8 metres above GL and connecting each panel with the adjoining panels with nut and bolts or other suitable means.

h) Suitable provision of frame/posts in the openings provided in barricading shall be made for receiving door shutter (payable separately) at locations as approved by Engineer-in-Charge.

1.1.5.3 Measurements:

Length of barricading shall be measured in running metres correct to a centimeter. No deduction shall be done for such openings made in the barricading, where door frame or posts have been separately provided to receive door shutter.

1.1.5.4 Rates:

The rates shall cover cost of all materials, labour and T&P involved in all the operations described above including its removal after the work duration. The removed material shall remain the property of the contractor.

1.1.6 PROTECTIVE BARRICADING USING BALLIS OR WOODEN VERTICALS AND CGI SHEET PANELS:

PURPOSE: *To provide a barricading on ground to physically define the boundaries*

of the site of construction/repair activity for restricted entry of only those involved with the construction work

1.1.6.1 Materials:

Available Corrugated G.I. Sheet minimum 24 G thick, Framing structural material comprising of minimum 100 mm dia ballis, nails, Galvanised J-hooks and other related accessories

1.1.6.2 Fabrication& Erection:

Work shall be carried out according to Para 1.1.5.2

1.1.6.3 Measurements:

As per Para 1.1.5.3

1.1.6.4 Rates:

The rates shall cover cost of all materials, labour and T&P involved in all the operations described above including its removal after the work duration. The removed material shall remain the property of the contractor.

1.1.7 PROTECTIVE BARRICADING USING BAMBOO AND LOCALLY AVAILABLE PANELS:

PURPOSE: *To provide a barricading on ground to physically define the boundaries of the site of construction/repair activity for restricted entry of only those involved with the construction work*

1.1.7.1 Materials:

Locally available bamboo panelling material or equivalent,

Framing structural material comprising of minimum 100 mm and 75 mm dia ballis/ bamboos, nails, Galvanised J-hooks and other related accessories and fixtures

1.1.7.2 Fabrication& Erection:

Work shall be carried out according to Para 1.1.5.2

1.1.7.3 Measurements:

As per Para 1.1.5.3

1.1.7.4 Rates:

The rates shall cover cost of all materials, labour and T&P involved in all the operations described above including its removal after the work duration. The removed material shall remain the property of the contractor.

1.1.8 TEMPORARY PROTECTIVE FABRIC SCREENS:

PURPOSE : *To protect passersby from falling debris and also to protect the workmen and structure being repaired against direct exposure to sun.*

1.1.8.1 Materials

For screening purpose jute cloth, woven PVC cloth, geo-textile or wire-mesh as specified and approved by Engineer-in-Charge shall be used, which shall conform to their relevant

BIS Code. Screen materials shall be fixed by suitable means comprising of M.S.Flats/ J-bolts /nails/clamps, etc with washer or any other suitable means on frames of existing scaffolding etc.

1.1.8.2 Procedure

- Scaffolding, if required, comprising of verticals, horizontals and diagonal bracings of steel tubes shall be fixed over ground as per Para 1.1.3 which is payable separately.
- One end of the screening material, brought to site in looms/rolls, shall be properly fixed over top horizontal member with suitable means and suspended so as to cover the required area.
- The vertical fall of screen shall be suitably fixed/firmed up at intermediate levels so as to keep it in position during the work duration.
- Next strip of the screening material shall be fixed with its sides stitched or suitably jointed or lapped with the previous ones as approved by Engineer-in-charge.
- Spacing of frame member of scaffolding shall be so selected that the sagging of screen shall not hinder the repair process.
- The contractor shall maintain the protective screens in acceptable conditions for the entire work duration as required by the Engineer-in-Charge.

1.1.8.3 Measurement

Length and height of screen shall be measured correct to a centimeter and area shall be worked out in square metres, correct up to second place of decimal.

1.1.8.4 Rate

The rates shall cover cost of all materials, labour and T&P involved in all the operations described above including its removal after the work duration. The removed material shall remain the property of the contractor.

1.1.9 PROVIDING AND FIXING DOOR OF CORRUGATED OR STIFFENED PLAIN GI SHEET OVER FRAME OF LOCAL WOOD ETC. :

PURPOSE: *To provide door shutter to temporary covered shelters, stores, yard, openings of temporary barricading etc.*

1.1.9.1 Material

a) Door frame shall be local acceptable wood or structural steel of section & size as approved by Engineer-in-charge and shall be free from warp, bend and shall have smooth surface.

b) Corrugated GI sheet conforming to IS-277 with thickness not less than 24 gauge or plain GI sheet stiffened by cold pressing

c) Hinges, aldrops, nails/screws etc.

1.1.9.2 Fabrication:

a) Wooden/structural steel frame shall be made of at least three horizontal members as bottom, middle and top rail and two vertical members as styles suitably jointed with diagonal members, if necessary.

b) Corrugated GI sheet or plain GI sheet shall be aligned such that its corrugation are vertical and fixed suitably with the help of nails /screws, nuts, bolts, washers, etc and fixed to door opening.

c) One coat of red oxide zinc chromate primer and one coat of paint shall be applied over GI sheet/steelwork and approved wooden primer and paint shall be applied over woodwork.

1.1.9.3 Fixing:

a) Door shutter shall be fixed to the existing frame with the help of approved hinges and screws of size, numbers and shape suitable for the size of door.

b) Approved aldrop shall be fixed to door shutters to make safe locking arrangements

c) If required by Engineer-in-Charge additional aldrops/tower bolts /other suitable device shall be fixed to the door shutters for ensuring safety.

d) If the GI sheet and /or horizontal rails are already painted, these shall be provided at least one finishing coat of paint to give it a uniform shade. On new work, one coat of primer and paint shall be applied.

1.1.9.4 Measurements

Finished dimensions of door shutter shall be measured correct to a centimeter and area worked out in square metres correct to second place of decimal.

1.1.9.5 Rate

The rates shall cover cost of all materials, labour and T&P involved in all the operations described above including its removal after the work duration. The removed material shall remain the property of the contractor.

1.1.10 PROVIDING AND ERECTING COVERED SHELTERS:

PURPOSE: *Erection of temporary shelters for storage of materials, T&P, etc incidental to carrying out the structural repairs, which require their protection during storage against extreme weather conditions.*

1.1.10.1 Materials

- Corrugated GI Sheets or wooden panels/boards
- Steel /timber/bamboo frame work as may be specified and approved by
- Engineer-in-Charge.
- Bricks
- Ordinary Portland Cement, Sand, any other construction material as may be required for construction of temporary shelters as per approved design.
- Necessary electrical connection, wiring & fittings essential for lighting, ventilation. Arrangements for cooling, heating etc to maintain humidity and temperature as per special material storage requirements.

1.1.10.2 Procedure:-

- The location, size and specifications of temporary covered shelters shall be got approved from the Engineer-in-Charge with justification of their use for storage of manufactured repair chemicals during carrying out of repairs. These shall be constructed to serve the

purpose intended and in accordance with Para 1.0.2.

- The shelters shall be made according to the approved plan, size, plinth level and a desirable average ceiling height of 3.3 metres or as may be approved by Engineer-in charge and with approved materials.
- Floor shall be pucca and kept sufficiently high to protect materials against weather, inundation etc.
- Necessary door, window and ventilator openings with frames to receive door shutters shall be kept in the side walls.
- If necessary, the required grills, window and ventilator shutters, with necessary fittings shall also be provided for ensuring the safety of stored materials.
- The electrical connection, wiring, fittings, etc as may be required and approved by the Engineer-in-charge for lighting, ventilation, temperature and humidity control shall be provided and fixed therein.
- At least one coat of approved primer and paint shall be applied on the inside and outside to give it a finishing touch and redoing it periodically, if necessary, to keep it in neat and tidy condition for the work duration

1.1.10.3 Measurements:

The overall plan dimensions of the covered shelters shall be measured correct to a centimeter and the area of the covered shelters shall be worked out in square metres correct to second place of decimal.

1.1.10.4 Rates:

The rates shall cover cost of all materials, labour and T&P involved in all the operations described above including its removal after the work duration. The removed material shall remain the property of the contractor.

1.2 SURFACE PREPARATION

1.2.1 REMOVAL OF PLASTER MANUALLY FROM MASONRY OR CONCRETE SURFACE USING CHISEL AND HAMMER AND DISPOSAL OF DEBRIS ETC. :

PURPOSE: *For removal of all type of loose /delaminated /damaged/weak cement plaster from surface of masonry or concrete.*

1.2.1.1 Procedure

Step-1 **Safety shall be ensured in accordance with Para 1.0.5**

Step-2 **Provide double scaffolding,** if necessary for heights above 3.0 metres Refer Para 1.1.3) .

Step-3 **Provide protective screens,** if necessary (Refer Para No 1.1.8).

Step-4 **Existing plaster to be to be identified for removal** by tapping all areas and its boundary shall be marked with a colour marking (Refer Fig 6.1a), which shall be approved by Engineer-in-Charge.

Step-5 **Make a cut normal to the surface** all along the boundaries with power driven cutters. The depth of cut shall not exceed the thickness of plaster.

Step-6 **Remove the plaster manually** with the help of chisel and hammers to completely expose the parent masonry or concrete surface, so as not to have any traces of such plaster left behind.

1.2.1.2 Measurement

The dimensions of removed plaster patch shall be measured correct to a centimeter and area shall be worked out in square metres correct to second place of decimal. The lead of disposal shall be measured in metres and rounded off to nearest multiple of 50 metres.

1.2.1.3 Rate

The rates shall cover cost of all materials, labour and T&P involved in all the operations described above except those involved in steps 2 and 3.

122 CHIPPING OF UNSOUND/WEAK CONCRETE MATERIAL:

PURPOSE: *To remove weak, loose or carbonated concrete over an area from its surface with pneumatically operated or power driven tools by chiselling, chipping etc.*

1.2.2.1 Materials and T&P:

Power or pneumatically driven chisel, chipping tools complete with accessories, hand-tools like chisels, hammer, pH indicator (0.2% phenolphthalein solution) with pH range at least up to 10.5, clinical injection syringe.

1.2.2.2 Safety: Safety shall be ensured in accordance with Para 1.0.5

1.2.2.3 Procedure:

Step-1 **Prop and support** (Refer Para 1.1.1) to relieve the structural member of stress and strains.

Step-2 **Scaffolding** (Refer Para no 1.1.3), if necessary for the exterior members, shall be done for working upon the area.

Step-3 **Working Platforms** for interior members, if necessary, shall be erected suitably or provided as mobile.

Step-4 **Provide Protective Screen, if necessary** (Refer Para 1.1.8).

Step-5 **Mark off the area** to be repaired using straight lines between corners. The marked area shall have 90^{o} corners with the sides parallel or normal to the direction of the reinforcement. The marked boundaries for the repair area should be a minimum of 50 mm outside the perimeter of the spall. For a single spall, the repair area should have a minimum width of 100mm in any direction. If a number of spalls are closely located to each other, these spalls should be included in a single area marked for repair (Refer Fig 6.1a).

Step-6 **Cut shall be made along the marked boundary,** normal-to-the surface. It should be made with a diamond cutter blade. However, when diamond cutting is not practical, the normal cut can be made with a power driven chisel. Minimum depth of cut shall be 10 mm. In situations where the diamond saw could cut into the reinforcing steel due to inadequate concrete cover, the boundary edge should be formed manually by means of chisel and impact hammers. A cover meter could be used to estimate the depth of cover.

Step-7 **Chipping to remove all the unsound and weak concrete** material shall be done carefully from the damaged portions of structural members by adopting mechanical or manual means up to the required depth to produce sound concrete surface to a near uniform depth for the repair area.

Tolerance: The chipping tolerances shall be ± 5mm

Chiselling Hand Tools are typically applicable for concrete removal for smaller, moderate and areas of limited access. Removal should begin at the interior of the repair area and progress toward the boundaries, using suitable hammer.

Power Driven Chisels/Hammers are normally applicable for chiselling smaller thicknesses up to about 50 mm.

Pneumatic Hammers are normally applicable for chiselling larger thicknesses in excess of 50 mm

Mechanical Milling (single drum, rotary cutter head with Tungsten–carbide bits) is applicable for large areas where the concrete cover is to be removed. Care must be taken to avoid contact with the reinforcing steel as both the reinforcement and the cutter drum could be damaged.

Rounded And Feathered Edges should be hand cut to form normal-to-the-surface boundaries. All the edges and cavities shall be square shouldered.

Step-8 **Test for carbonation** shall be carried out at embedded or exposed reinforcement locations, by spraying phenolphthalein indicator on concrete in contact and in the immediate vicinity of reinforcement ***soon after its chipping.*** As otherwise, chipped concrete surface in contact with air is likely to get carbonated soon after its coming in contact with atmospheric carbon dioxide.

Step-9 **A full-depth chiselling and removal of concrete** all round reinforcement shall be carried out, in case the concrete in contact and in immediate vicinity of the reinforcement is carbonated (Refer Para no 1.2.6).

Step-10 **Inspection and soundness testing,** after concrete removal & cleaning, for weaknesses and delamination of exposed surfaces shall be visually carried out. If required, additional removal will be done.

Step-11 **Cleaning of debris and dust** shall be carried out from within the chiselled/ chipped area and its disposal as per direction of the Engineer-in-Charge.

1.2.2.4 Measurements:

The dimensions of the area chipped off for RCC slabs, beams and columns shall be measured separately. The average thickness shall be determined by taking an average of five thickness readings recorded with one reading each at corner and at the point of intersection of wires stretched diagonally from corner points of the rectangular area chipped. The extra/less thickness than specified for slabs, beams and columns shall be recorded in millimeters. Corresponding areas of slab, beam and columns shall be separately worked out in square meters correct to second place of decimal. The lead of disposal shall be measured in metres and rounded off to nearest 50 metres.

1.2.2.5 Rates:

The rates shall cover cost of all materials, labour and T&P involved in all the operations described above except those involved in steps 1, 2, 4, 8 and 9.

1.2.3 DISMANTLING & REMOVING EXISTING TREATMENT OVER RCC SLABS AT ALL HEIGHTS:

PURPOSE: *Removal of any type of existing surface treatment e.g roofing, water proofing treatment, flooring, etc over RCC slabs at all heights*

1.2.3.1 Materials and T&P:

Power or pneumatically driven chiselling, chipping tools complete with accessories, hand-tools like chisels, hammer.

1.2.3.2 Procedure:

Step-1 **Carefully remove** the identified portion of the existing surface treatment over the RCC slab with required chipping, chiselling tools without causing excessive vibrations or damaging the structure. Para 1.2.2.3 generally applies.

Step-2 **Stack the serviceable material** for reuse as directed by the Engineer-in-charge.

Step-3 **Dispose off the balance material** as per the direction of Engineer-in-charge.

1.2.3.4 Measurements:

The surface area of RCC slab exposed shall be measured correct to a centimeter and area worked out in square metres correct to second place of decimal. The lead of disposal shall be measured in metres and rounded off to nearest multiple of 50 metres.

1.2.3.5 Rates:

Rates cover all labour, materials and T&P involved in the operations involved as above.

1.2.4 DISMANTLING EXISTING RCC WORK BUT EXCLUDING CUTTING REINFORCEMENT BARS:

PURPOSE: *Dismantling of RCC structural members using hand tools as may be required for rehabilitation/repair.*

1.2.4.1 Materials and T&P:

Concrete breaking hand tools like Chisels, Hammers and related tools complete with incidental accessories.

1.2.4.2 Safety: Safety shall be ensured in accordance with Para 1.0.5

1.2.4.3 Procedure:

Step-1 **Identify the RCC portion** to be dismantled as approved by Engineer-in-charge.

Step-2 **Prop and support** (Refer Para 1.1.1)**,** if not done already, to relieve the structural member of stress and strains.

Step-3 **Scaffolding & working platforms** for the exterior members (Refer Para 1 .1.3), if not already done and if necessary, shall be erected for working upon the area.

Step-4 **Working Platforms** for interior members, if not already done and if necessary, shall be erected suitably or provided as mobile.

Step-5 **Provide Protective Screens** (Refer Para 1.1.8), if not already done and if necessary.

Step-6 **Carefully remove only the RCC** i.e. concrete portion with the hand tools/ mechanically without causing excessive vibrations or damaging the structure.

Do not cut the embedded reinforcement, if any, but shall be cleaned of concrete. However, the loose reinforcement shall be recovered for use.

Step-7 **Dismantling to remove all the unsound and weak concrete** material shall be done carefully from the damaged portions of structural members by adopting

mechanical or manual means up to the required depth to produce sound concrete surface to a near uniform depth for the repair area.

Chiselling Hand Tools are typically applicable for concrete removal for smaller, moderate and areas of limited access. Removal should begin at the interior of the repair area and progress toward the boundaries, using suitable hammer.

Power Driven Chisels/Hammers are normally applicable for chiselling smaller thicknesses up to about 50 mm.

Pneumatic Hammers are normally applicable for chiselling larger thicknesses in excess of 50 mm

Step-8 **Stack the reinforcement, if recovered** for reuse in step-6 and balance material disposed off as per the direction of Engineer-in-charge.

1.2.4.4 Measurements:

Pre-measurements of the dimensions of RCC to be dismantled shall be recorded before taking up the dismantling operations and shall be measured correct to a centimeter and volume worked out in cubic metres correct to second place of decimal. The lead of disposal shall be measured in metres and rounded off to nearest multiple of 50 metres.

1.2.4.5 Rates:

Rates cover all labour, materials, T&P involved in the operations involved as above except those involved in steps 2, 3 and 5.

1.2.5 CUTTING REINFORCING BARS IN RCC OR REINFORCED BRICKWORK:

PURPOSE: *To cut visible portion of embedded reinforcing bars in RCC or Reinforced Brickwork using hand tools.*

1.2.5.1 Materials and T&P:

Reinforcing cutting/shearing hand tools like hacksaw, chisels, hammer and related tools complete with incidental accessories.

1.2.5.2 Safety: Safety shall be ensured in accordance with Para 1.0.5

1.2.5.3 Procedure:

Step-1 **Identify the visible reinforcing bars** required to be cut, which shall be approved by Engineer-in-charge.

Step-2 **Carefully cut/shear** the reinforcing bars with the hand tools without causing excessive vibrations or damaging the structure.

Step-3 **Stack the reinforcement recovered** for reuse as per the direction of Engineer-in-charge

1.2.5.4 Measurements:

Pre-measurements of the number of reinforcing bars to be cut shall be recorded in three categories of diameters e.g. upto 12 mm, above 12 mm and not exceeding 20 mm and those exceeding 20mm.

1.2.5.5 Rates:

Rates cover all labour, materials, T&P involved in the operations involved as above and stacking the reusable material within a lead of 50 metres.

1.2.6 REMOVING CONCRETE ALL AROUND REINFORCEMENT INCLUDING FROM ITS BEHIND:

PURPOSE: *To create an average clear air gap equal to nominal size of coarse aggregate plus 5 mm all around embedded reinforcement, in contact with carbonated concrete for rust removal & passivating its surface with fresh alkaline passivating coat and concrete/ mortar.*

1.2.6.1 Materials and T&P:

Power or pneumatically driven chiselling, abrading, chipping tools complete with accessories, hand-tools like chisels, hammer, pH indicator i.e. 0.2% solution of phenolphthalein indicator for pH range preferably up to 11.5 or at least up to 10.5, clinical injection syringe.

1.2.6.2 Safety:

Safety shall be ensured in accordance with Para 1.0.5.

1.2.6.3 Procedure:

Step-1 **Prop and support** (Refer Para 1.1.1)**,** if not done already, to relieve the structural member of stress and strains.

Step-2 **Scaffolding & working platforms** for the exterior members (Refer Para 1.1.3), if not already done and if necessary, shall be erected for working upon the area.

Step-3 **Working Platforms** for interior members, if not already done and if necessary, shall be erected suitably or provided as mobile.

Step-4 **Provide Protective Screen** (Refer Para 1.1.8), if not already done and if necessary.

Step-5 **Test for carbonation** shall be carried out at embedded or exposed reinforcement locations, by spraying phenolphthalein indicator on *freshly chipped* concrete in contact and in the immediate vicinity of reinforcement.

Step-6 **A full-depth chiselling and removal of concrete** all round reinforcement shall be carried out, if the concrete in contact and in immediate vicinity of the reinforcement is carbonated.

The concrete around reinforcement shall be removed so as to have a near uniform air gap of about 5 mm plus the nominal size of coarse aggregate to be used in repair concrete/mortar. However, the air gap shall not be less than 15 mm in any case.

Power/pneumatic driven tools/chisels shall be used for such portions of carbonated concrete around reinforcement, which could not be removed manually, to achieve a near uniform required air gap all around including behind the reinforcement.

Power Driven Chisels/Hammers are normally applicable for chiselling smaller depths up to about 50 mm.

Pneumatic Hammers are normally applicable for chiselling larger depth in excess of 50mm

Step-7 **Cleaning of debris and dust** shall be carried out from within the chiselled /chipped area and its disposal as per direction of the Engineer-in-Charge.

1.2.6.4 Measurements:

The reinforcing bars cleaned of concrete shall be grouped in two diawise categories, i.e. upto and including 12 mm and the other in excess of 12 mm. For each of such categories of bars, length cleaned of concrete all around, shall be separately measured for cleaning manually and using standard power/pneumatically driven abrading/chiselling tools. The length shall be measured in metres correct up to second place of decimal.

1.2.6.5 Rates:

The rates shall cover cost of all materials, labour and T&P involved in all the operations described above except those involved in steps 1, 2 and 4.

1.2.7 CLEANING REINFORCEMENT OF TOTAL RUST INCLUDING FROM BEHIND REINFORCEMENT:

1.2.7.1 Materials and T&P:

Chiselling, abrading, chipping, hammering, wire brushes, paint brush, abrading cloth, etc hand tools complete with accessories, tested and approved alkaline chemical rust remover.

1.2.7.2 Testing:

Chemical rust remover shall be tested to ensure that it is an alkaline material with its pH more than 11.5 and for its efficacy by a sample of rust removal.

Sand to be used for sand blasting shall conform to Zone-I or II of IS:383

1.2.7.3 Safety:

Safety shall be ensured in accordance with Para 1.0.5

1.2.7.4 Procedure:

Step-1 **Remove the rust manually** from all round the surface along the length of reinforcement, using hand tools like chisels, hammers, wire brushes, abrading cloth/paper, etc. This shall be continued manually along the length of the rusted reinforcement till such time that the steel surface is cleared of all rust that could be removed manually.

Step-2 **Remove the Rust by sand blasting and/or using tested chemicals,** if directed by Engineer-in-Charge, due to unsatisfactory results of manual rust removal.

A. By sand blasting:
Coarse sand shall be sprayed under pressure over the exposed

reinforcement so as to cause an intense abrading of the reinforcement surface and removal of rust from its entire surface to achieve shining bright metal.

B. Using tested chemicals:

Chemical rust remover shall be brush applied over the reinforcement surface thoroughly all around the circumference and along the full length of rusted reinforcement. After 24 hours of its application, the surface shall be cleaned with wire brush and all loose particles removed. It shall be washed with water thoroughly and allowed to dry.

1.2.7.5 Measurements:

The reinforcing bars cleaned of concrete shall be grouped in two diawise categories, i.e. upto and including 12 mm and above of 12 mm. For each of such categories of bars, length cleaned of rust all around, shall be separately measured for cleaning manually, using sand blasting and using alkaline chemical rust remover. The length shall be measured in metres correct up to second place of decimal

1.2.7.6 Rates:

The rates shall cover cost of all materials, labour and T&P involved in all the operations described above.

1.2.8 INTRODUCING NEW REINFORCEMENT BARS FOR STRUCTURAL CONNECTION IN RCC STRUCTURAL MEMBER:

PURPOSE: *For introducing additional reinforcing bars for new structural connection or supplementing additional steel area to existing RCC beams, lintels, columns for cantilevers, chajjas, etc or alike.*

1.2.8.1 Material and T&P:

1. Epoxy cartridges and specified steel reinforcement.
2. Standard Power driven drilling/hammering equipment
3. Hand operated blow out pump, brushes, epoxy dispenser, epoxy cartridge holder, disposable PVC mixing nozzle for epoxy, and any other incidental accessories and T&P items.

1.2.8.2 Testing:

The epoxy in the cartridges shall be subjected to testing for its conformity to the manufacturer's specifications.

The power drilling/hammering equipment, drill bits, etc shall be tested for their effective functioning.

1.2.8.3 Procedure

Step 1 **Design** additional cross-sectional area required and get them approved from the Engineer-in-Charge.

Step-2 **Cross sectional area of steel reinforcement** provided for new structural connection or for supplementing the existing cross-sectional area shall be as per approved design/drawings.

Step 3 **Provide the depth of embedment of the reinforcing bar** in concrete as specified in the approved design/drawings. Based on assessed strength of concrete, Tables 1.8 to 1.10 could be used as a guide for assessment of the depth of embedment of steel reinforcing bar. The strength of concrete shall be determined quantitatively by core test or capo test for ensuring reliability, which shall be paid for separately.

Step 4 **Prepare the surface** of the existing RCC member to receive the structural connection as per Para 1.2 and its sub paras.

Step 5 **Mark the new reinforcing bar locations** on prepared surface for fixing.

Step 6 **Drill holes of specified diameter and depth** in concrete at locations marked as per approved design calculations. Tables 1.8 to 1.10 are rough guide corresponding to the grade of existing concrete and diameter of the steel reinforcement.

Step 7 **Clean the drilled hole** in dry state with round brushes and by blowing air through a tube inserted in the hole and connected to hand operated blow out pump (Fig. 1.1).

Step 8 **Inject epoxy from the foil pack** with the help of epoxy dispenser, epoxy cartridge holder and disposable PVC mixing nozzle inserted inside the drilled hole to fill it from bottom of the hole and upwards. The approximate consumption of the epoxy in cubic cm. is given in Table 1.11 as a general guide.

Step 9 **Insert the reinforcing bar** and allow the epoxy adhesive to cure.

1.2.8.4 Measurements:

Number of reinforcing bars introduced/inserted shall be measured in three separate groups for bars upto and including 12 mm dia, more than 12 mm but not exceeding 20 mm dia and all bars with dia more than 20 mm.

1.2.8.5 Rates:

The rates shall cover cost of all materials, labour and T&P involved in all the operations

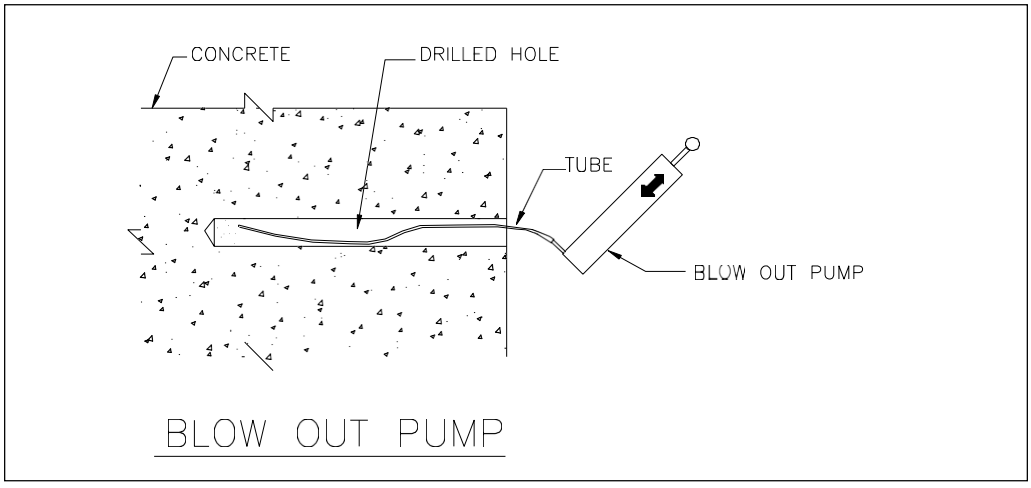


Fig 1.1: Hand Operated Blowout Pump

Concrete Grade M 20; Yield Strength of Steel 415 N/mm²

(Source: Literature of Hilti India Ltd.)

Rebar Dia	Hole Dia	Depth of Hole	Recommended Tensile Load of Rebar Frec (Kn)																
(in mm)	(in mm)		100	120	140	160	180	200	220	240	270	300	330	370	400	450	500	600	850
8	12		9.73	11.6	12.09	12.09	12.09	12.09	12.09	12.09	12.09	12.09	12.09	12.09	12.09	12.09	12.09	12.09	12.09
10	14		10.51	12.62	14.72	16.82	18.90	18.90	18.90	18.90	18.90	18.90	18.90	18.90	18.90	18.90	18.90	18.90	18.90
12	16			13.49	15.74	17.98	20.23	22.48	24.73	26.98	27.21	27.21	27.21	27.21	27.21	27.21	27.21	27.21	27.21
14	18				16.69	19.07	21.46	23.84	26.23	28.61	32.19	35.76	37.09	37.03	37.03	37.03	37.03	37.03	37.03
16	22					21.09	23.72	26.36	29.00	31.63	35.59	39.54	43.49	48.37	48.37	48.37	48.37	48.37	48.37
20	28							29.74	32.71	35.68	40.15	44.61	49.07	55.01	59.47	66.91	74.34	75.58	75.58
25	32										42.92	47.69	52.45	58.81	63.58	71.53	79.48	95.37	118.09

Partial Safety Factor for Steel = 1.15, for Variable actions = 1.5

Table 1.9

Concrete Grade M25; Yield Strength of Steel 415 N/mm^2

(Source: Literature of Hilti India Ltd.)

Rebar Dia	Hole Dia	Depth of Hole	Recommended Tensile Load of Rebar Frec (Kn)															
(in mm)	(in mm)		100	120	140	160	180	200	220	240	270	300	330	370	400	450	500	600	850
8	12		9.87	11.85	12.09	12.09	12.09	12.09	12.09	12.09	12.09	12.09	12.09	12.09	12.09	12.09	12.09	12.09	12.09
10	14		11.04	13.25	15.45	17.66	18.90	18.90	13.90	18.90	18.90	18.90	18.90	18.90	18.90	18.90	18.90	18.90	18.90
12	16			14.51	16.93	19.35	21.77	24.18	26.60	27.21	27.21	27.21	27.21	27.21	27.21	27.21	27.21	27.21	27.21
14	18				18.29	20.90	23.51	26.12	28.73	31.35	35.26	37.03	37.03	37.03	37.03	37.03	37.03	37.03	37.03
16	22					22.34	25.13	27.93	30.72	33.51	37.70	41.89	46.08	48.37	48.37	48.37	48.37	48.37	48.37
20	28							31.22	34.34	37.47	42.15	46.83	51.52	57.76	62.44	70.25	75.58	75.58	75.58
25	32										47.12	52.36	57.60	64.58	69.81	78.54	87.27	104.72	118.09

Partial Safety Factor for Steel = 1.15 for Variable actions = 1.5

Values for the above table remain same for all subsequent higher grade of concrete.

Concrete Grade M30; Yield Strength of Steel 415 N/mm^2

(Source: Literature of Hilti India Ltd.)

Rebar Dia	Hole Dia	Depth of Hole	Recommended Tensile Load of Rebar Frec (Kn)																
(in mm)	(in mm)		100	120	140	160	180	200	220	240	270	300	330	370	400	450	500	600	850
8	12		9.87	11.85	12.09	12.09	12.09	12.09	12.09	12.09	12.09	12.09	12.09	12.09	12.09	12.09	12.09	12.09	12.09
10	14		11.04	13.25	15.45	17.66	18.90	18.90	18.90	18.90	18.90	18.90	18.90	18.90	18.90	18.90	18.90	18.90	18.90
12	16			14.51	16.93	19.35	21.77	24.18	26.60	27.21	27.21	27.21	27.21	27.21	27.21	27.21	27.21	27.21	27.21
14	18				18.29	20.90	23.51	26.12	28.73	31.35	35.26	37.03	37.03	37.03	37.03	37.03	37.03	37.03	37.03
16	22					22.34	25.13	27.93	30.72	33.51	37.70	41.89	46.08	48.37	48.37	48.37	48.37	48.37	48.37
20	28							31.22	34.34	37.47	42.15	46.83	51.52	57.76	62.44	70.25	75.58	75.58	75.58
25	32										47.12	52.36	57.60	64.58	69.81	78.54	87.27	104.72	118.09

Partial Safety Factor for Steel = 1.15 for variable actions -= 1.5

Table 1.11

Epoxy Requirement for Rebar Embedment

Rebar Dia	**Hole Dia**	**Depth of Hole**	**REBAR APPLICATION Consumption in cm^3 (ml)**															
(in mm)	(in mm)	100	120	140	160	180	200	220	240	270	300	330	370	400	450	500	600	850
8	12	9	10	12	14	16	17	19	21	23	26	29	32	36	39	43	52	74
10	14	10	12	14	16	18	20	22	24	27	30	33	37	40	45	51	61	86
12	16	12	14	16	18	21	23	25	28	31	35	38	43	46	52	58	69	98
14	18	13	16	18	21	23	26	29	31	35	39	43	48	52	58	65	78	110
16	22	24	29	33	38	43	48	52	57	64	71	79	88	95	107	119	143	203
20	28	40	49	57	65	73	81	89	97	109	121	133	150	162	182	202	243	344
25	32	40	49	57	65	73	81	89	97	109	121	133	150	162	182	202	243	344

described above.

1.2.9 SPECIFICATION FOR PROVIDING AND INSERTING SHEAR KEY BARS:

PURPOSE: *Shear key bars are used for providing a structural connection of the applied repair material with the substrate/parent surface for transfer of forces occurring at the interface.*

1.2.9.1 Materials and T&P:

1. Epoxy cartridges and specified lengths and diameter of steel reinforcement.
2. Standard Power driven drilling/hammering equipment

Hand operated blow out pump, brushes, epoxy dispenser, epoxy cartridge holder, disposable PVC mixing nozzle for epoxy, and any other incidental accessories and T&P items.

1.2.9.2 Procedure

Step 1: **Mark the locations of shear keys and get the same approved** for structural connection from the Engineer-in-charge.

Step 2: **Drill holes to specified depth and diameter in concrete** at marked locations for the specified dia of shear key bars.

Step 3: **The drilled hole in dry state shall be cleaned** with round brushes and by blowing air through a tube inserted in the hole and connected to hand operated blow out pump (Fig. 1.1).

Step 4: **Inject epoxy from the foil pack** with the help of epoxy dispenser, epoxy cartridge holder and disposable PVC mixing nozzle inserted inside the drilled hole to fill it from bottom of the hole and upwards. The approximate consumption of the epoxy in cubic cm. is given in Table 1.11 as a general guide.

Step 5: Insert the reinforcing bar and allow the epoxy adhesive to cure.

1.2.9.3 Measurements:

Measurements shall be done in number of specified bars introduced in two separate groups for shear key bars of 12 mm dia and 16mm dia bars.

1.2.9.4 Rates:

The rates shall cover cost of all materials, labour and T&P involved in all the operations described above.

1.2.10 SPECIFICATION FOR CLEANING EXPOSED CONCRETE SURFACE OF LOOSE AND FOREIGN MATERIALS BY MEANS OF SAND BLASTING:

PURPOSE: *To clean the prepared concrete surface of all-loose, lightly sticking materials, including the foreign materials, loose concrete, aggregates etc so as to provide a good bond with the applied repair material.*

1.2.10.1 Materials and T&P:

Coarse sand conforming to Zone I or II as per IS: 383, Air compressor of a minimum 35 Kilowatt capacity, spray gun for sand, all related accessories for sand blasting, hand tools like wire brushes, chisels, etc

1.2.10.2 Testing of Materials and T&P:

The sand shall be tested to conform to the specification.

The air compressor shall be tested to perform to the required standards as laid down in Para 1.5.2.1.2 subsequently.

1.2.10.3 Safety:

Safety shall be ensured in accordance with Para 1.0.5.

1.2.10.4 Procedure:

Step-1: **Specified tested coarse sand shall be collected at site** in required quantity for sand blasting.

Step-2: **Make available mechanical power driven air compressor** in working condition at site with all required accessories for carrying out sand blasting as well as air blasting operations.

Step-3: **Clean the final chipped off concrete** surface and exposed reinforcement, if any, of all loose and foreign materials to be subsequently followed with oil free air blast.

1.2.10.5 Measurements:

Length and breadth of the area cleaned by sand blasting shall be recorded correct to a centimeter and area worked out in square metres correct to second place of decimal.

1.2.10.6 Rates:

The rates shall cover cost of all materials, labour and T&P involved in all the operations described above.

1.2.11 PROVIDING AND FIXING ANCHOR FASTNER SYSTEM MECHANICAL/ EPOXY BASED:

PURPOSE: *To provide an anchor fastner to be able to resist a known pull out force. The anchor fastner system shall be standard system with minimum guaranteed load carrying capacities for a given substrate.*

1.2.11.1 Materials and T&P:

As per the proprietary firm and as specified.

1.2.11.2 Testing:

The designated capacity of the mechanical/epoxy based anchor fastener shall be tested by appropriate pull out strength measurement device.

1.2.11.3 Procedure:

As per the proprietary firm and as specified.

1.2.11.4 Measurement:

Measurements shall be done in number of fastners complete for each category, diameter wise of the anchor fastner system separately for mechanical and epoxy based system.

1.2.11.5 Rates:

The rates shall cover cost of all materials, labour and T&P involved in all the operations described above.

1.3 CRACK/HONEYCOMB AREA REPAIR

1.3.1 SPECIFICATION FOR PROVIDING DRILLING AND INSERTING NIPPLES ALONG CRACK LINES:

PURPOSE: *To fix injection nipples and seal the remaining portion of honey combed or cracked concrete /masonry for grout injection.*

1.3.1.1 Materials and T&P:

12 mm diameter approved aluminium /Galvanised Iron nipples, Chisel, hammer, power driven tool for chase cutting & drilling, hand operated blow out pump, sealing putty of polyester/epoxy/polymer modified mortar etc. and all related accessories and materials.

1.3.1.2 Testing:

The sealing putty and the nipples shall be tested to conform to the manufacturers specifications.

The power driven tools shall be test driven and their drill/cutting bits shall be tested for effectiveness before taking up the repair operation.

1.3.1.3 Procedure:

Step-1: **Follow the guidelines** for Safety, Quality Assurance, Environmental Protection, Personnel, Supervision, Product delivery, Storage and Handling etc given in Para 1.0.

Step-2: **Identify the Cracks and mark the area** for injection grouting.

Step-3: **Prop & support** the structural member, if required, to relieve it of stress and strains (Refer Para 1.1.1)

Step-4: **Open up cracked surface** by making 'V' notch or groove of size 12 mm x 12mm.

Step-5: Remove plaster, if required, to identify and mark the honey combed area (Refer 1.2.1).

Step-6: **Drill holes** at least 25 mm diameter and 40mm deep

- along crack lines at spacing of 300 mm or thickness of the structural member, whichever is less.
- In honey combed area @ 9 nos per sqm. as directed by Engineer-in-Charge and upto 30 mm to 40 mm depth.

Step-7: **Remove coarse debris and dust** in opened up cracks and drilled holes by blowing oil free compressed air, if available with air compressor, otherwise with hand operated blow out pump. Concrete surfaces required to be grouted shall be free from all loose and unsound materials by means of mechanical abrasion using stiff wire brushes, after removing all loose areas with chissel

and hammer. Area shall be made free from any deleterious materials, such as oil dust dirt etc. by means of oil free jet of compressed air.
All prepared concrete surfaces shall be thoroughly inspected and got approved by the contractor.

Step-8: **Insert 12mm dia specified injection nipples** in holes drilled along crack lines and fix them by sealing only its sides with epoxy or polymer modified mortar.

Step-9: **Seal the crack or the honey combed surface** between the nipples by means of epoxy mortar after applying epoxy primer or polymer modified mortar as may be approved by Engineer-in charge. The epoxy/polymer used shall be of approved grade and applied as per specifications mentioned separately elsewhere. The epoxy mortar shall be air cured for 24 hours, whereas the polymer-modified mortar shall be moist cured for 1-3 days and allowed to gain strength before actual grouting commences.

1.3.1.4 Measurements:

For payment purposes, number of nipples fixed shall be separately measured for concrete and masonry work.

1.3.1.5 Rates:

The rates shall cover cost of all materials, labour and T&P involved in all the operations described above except those involved in above mentioned steps 3 and 5.

1.3.2 SEALING OF CRACKS BY INJECTION OF APPROVED GROUT:

PURPOSE: *To inject the specified grout into honeycombed or cracked concrete/ masonry*

1.3.2.1 Materials and T&P:

a. Specified grout

i. Cementitious Grout shall have following components:

Cement: The cement used shall be ordinary Portland cement of the specified grade and conforming the relevant BIS code of Practice.

Sand: The sand shall be sharp washed well graded generally falling in Zone IV of IS 383

Water: Water used for grout shall conform to the requirements of IS 456.

Admixture: If required, admixture shall be used only after the approval of Engineer-in-Charge, who shall be furnished with all the required literature pertaining to its efficacy. The mixture shall meet the requirement of IS 456 and IS 9103. Payment for admixture shall be made separately.

Polymer: It shall be as specified and shall conform to ASTM-C-1059 The physical and mechanical properties of polymers shall conform to Tables 5.4 and 5.5.

ii. **Epoxy Grout** shall conform to ASTM C-882 and have following properties:

Viscosity at 25°C maximum	- 2 Pas
Minimum Gel time	- 30 minutes
14 days bond strength at 25°C min.	- 3.5 MPa
Min. compressive strength	- 60 MPA at 7 days.
Tensile strength 7 days min.	- 45 MPa

b. **Hand/power operated grouting pressure pump/gun** with pressure gauge. The grouting equipment shall be capable of supplying, mixing, stirring and pumping grout to the satisfaction of the Engineer-in-Charge. The equipment shall have the capacity to inject grout at a pressure upto 7 kg per square centimeter measured at the grout connections. It shall be capable of mixing and pumping of cement sand grout 1:2 with water cement ratio ranging from 0.5 to 1.

c. **Air compressor** with all related accessories for carrying compressed air to the required location. Hand operated blow out pump may be allowed by Engineer-in-Charge for small crack depths/areas.

d. **Calibrated Spring Balance** (for accurately weighing different components of materials in required proportions),

e. **Mechanical blender** for mixing

f. **Spray equipment/brush** for application of epoxy/ polymer modified/ bonding cement slurry

1.3.2.2 Execution:

Step-1 **Follow the guidelines** for Safety, Quality Assurance, Environmental Protection, Product delivery, Personnel, Supervision, Storage and Handling, etc given in Para 1.0.

Step-2 **Full quantity of manufactured material (e.g. specified resin, hardener, polymer, cement, etc as may be required) shall be received** at site in factory sealed containers with labels legible and intact provided that the shelf life so permits. Otherwise substantial quantity as could be consumed within the storage period shall be received as per quantity approved by Engineer-in-Charge. Full quantity shall be worked out as theoretically required for consumption in the whole work.

Step-3 **Collect random samples of materials for test** and send to approved laboratories so as to ensure that they satisfy the physical and mechanical properties.

The grout pump and the pressure gauge shall be tested before taking up the repair operation.

Step-4 **Identify the Cracks and mark the area** for injection grouting.

Step-5 **Surface Preparation:** The appropriate propping/supporting, surface preparation and crack sealing as per site requirements shall be completed, which may sequentially cover one or more of the following items of work:

a) **Prop & support** the structural member to relieve it of stress and strains (Refer Para 1.1.1)

b) Provide grouting nipples (Refer Para 1.3.1).

Step-6 **Blow the compressed air followed by washing with water** through nipples located at the highest level and downwards to ensure removal of even fine dust particles from the cracked surface, which could obstruct the free flow of grout material and impede its bonding with cracked surface (and drying with air blast wherever epoxy injection grout is to be used).

Step-7 **Saturate the cracked surface** in the vicinity of crack/honeycombed concrete/ masonry with water (but without excess water), only if the cementitious grout is to be injected. Otherwise, this step may be skipped.

Step-8 **Prepare the injection grout** as under:

A EPOXY GROUT

Epoxy component shall be mixed in a clean container free from harmful residue or foreign particles. Epoxy component shall be thoroughly blended in a mechanical mixer to a uniform and homogeneous mixture. Small batches (upto 1 litre) however may be allowed for manual mixing using spatulas, pallattes, knives, etc.

B. CEMENT SLURRY

Mixes consisting of cement, water, sand and admixture like fluidifiers (of approved type) in the proportions directed by the Engineer-in-Charge who will, from time to time make changes to suit the conditions encountered in the particular grout work. The water cement ratio shall be varied to meet the characteristics of each hole as revealed by the grouting operations and will range between 0.5 and 1.0.

Shrinkage compensating cement slurry mixed to a lump free creamy consistency shall be made by thoroughly blending in a mechanical mixer and shall be continuously stirred mechanically to keep the cement particles in suspension to retain uniform consistency till the grout is injected. Only small batches (upto 1 litre) be allowed by manual mixing with spatulas, pallattes, knives, etc.

C. SBR/ACRYLIC POLYMER CEMENT SLURRY

Shrinkage compensating cement mixed with polymer and water, in specified proportion in conformity with Table 5.4. For other details it would be similar to preparation of cement slurry as given in preceding paragraph above.

Step-9 **Inject the approved & specified grout** into the cracks by means of suitable gun or pump at a pressure of 1- 2 kg./cm^2 for epoxy grout and 4-7 kg./cm^2 for cementitious grout.

In case of vertical cracks injection shall be started at the lowest nipple and continued until the injected grout begins to flow out at the next higher nipple. Whereas in other cases of horizontal locations, the injection shall be started from one nipple and continued until the injected grout begins to flow out at

the other nipple.

The first nipple shall then be closed off and injection continued at the second until the grout flows out at the third. The process shall be repeated until the whole of the crack has been sealed. As soon as the system is cured, the nipples shall be cut.

In case of Honeycombed Area, each grout hole shall be grouted individually. Grouting pressures to be used in the work will vary with the conditions encountered and different areas and the pressure used shall be between 1 to 4 kg/cm^2. The sequence of injection shall be as per the direction of Engineer-in-Charge

Step-10 **Pre and Post Repair Evaluation**

As per directions of the Engineer-in-Charge, the contractor shall carry out Ultrasonic Pulse Velocity Test (UPV) and core test in an approved manner prior to injection grouting and after injection and cure of the grout to ascertain the quality and efficacy of the grouting work. Cores from the post-repaired area shall be extracted only when UPV test results are reported satisfactory. For UPV test and Core test. Nomenclature of relevant items given in Sub Head- X of Chapter 8. Such tests carried out at one location prior to and after the grouting shall be considered as one test only and shall be carried out with at least one test for every 100 square metre of injection grouted surface area. The UPV and core tests shall be carried out only by experienced personnel/ agency.

Step-11 **Re-grout, based on test results**, if in the opinion of Engineer-in-Charge the condition of concrete along the path of grouting is not satisfactory, the contractor shall drill more holes at the locations as required by Engineer- in-Charge and re-grout the member according to the procedure laid down as above. The grouting operation shall be followed till the results of ultrasonic pulse velocity test and core test are satisfactory.

1.3.2.3 Measurements:

(a) **Material supplied:** The quantities of specified resin and hardener, polymers, cements etc supplied shall be recorded after satisfying acceptability criteria. The solid contents of Acrylic/SBR polymer shall be determined in field laboratory or designated laboratory for each batch of supply of latex received and recorded separately batch wise for determining the solid contents for the purpose of payment.

The measurements of weight of the grouting materials supplied shall be weight of resin plus hardener for epoxy; solid contents of polymer, cement for each batch of supplies received:

(b) **Grout Material Consumed:** The weight of the grout material shall include the gross weight of injected material for:

(i) Epoxy grout - weight of resin, hardener & silica sand

(ii) Polymer modified or plain cement sand slurry- weight of cement, sand, and solid contents of polymer & plasticiser, if any, but excluding the weight of mixed water.

(iii) Cement slurry- excluding the weight of mixed water.

The weight of grout shall exclude the quantity of water added directly or through the polymer emulsion.

Pre-measurements of the quantities of such grouting materials available or brought at site and the balance quantities remaining at the end of grouting application shall be recorded separately, which will determine the quantity of grout materials actually injected in to the crack/honeycomb area.

The quantities of grout material wasted, discarded, hardened shall not count for payment and shall be recorded for deduction at the end of each operation.

The measurements shall be separately recorded for concrete and masonry work.

1.3.2.4 Rates:

The rates shall cover cost of all materials, labour and T&P involved in all the operations described above except those covered by step-5. Cost of admixture shall be paid separately.

Note : In respect of materials supplies, two stage payment shall be made. In the first stage 75 % of the rates quoted be released after the materials are brought to site of work and tested satisfactorily. Balance 25 % of the rates quoted shall be released in the second stage, which will be after their consumption in the work.

1.4 BONDING COATS

1.4.1 BONDING COAT FOR HARDENED CONCRETE WITH REPAIR CONCRETE/ SHOTCRETE/ CEMENT MORTAR:

PURPOSE: *To provide adequately strong adhesion of parent concrete with applied repair concrete or mortar.*

1.4.1.1 Materials and T&P:

Specified bonding materials e.g. epoxy or polymer and cement, mixing water, necessary T&P for mixing and applying bond coat e.g. brush, spray gun, mixer, mechanical stirrer, etc

Product:

A) **Epoxy Adhesives** shall conform to ASTM C-882.

B) **Polymer Latex** shall conform to ASTM C-1059

C) **Cement** shall be ordinary Portland cement conforming to IS: 269

1.4.1.2 Execution:

Step-1 **Follow the guidelines** for Safety, Quality Assurance, Environmental Protection, Product delivery, Personnel, Supervision, Storage and Handling, etc given in Para 1.0.

Step-2 **Full quantity of manufactured repair materials shall be received** at site in factory sealed containers with labels legible and intact, if the shelf life so permits. Otherwise substantial quantity as could be consumed within the shelf

life shall be received as per quantity approved by Engineer- in-Charge. Full quantity shall be worked out as theoretically required for consumption in the whole work.

Step-3 **Prepare the surface** for treatment (Refer Para 1.2.1, 1.2.2, 1.2.6 and 1.2.7 as may be applicable).

Step-4 **Saturate the surface with water** but shall be free of excess surface water, debris and dust, where cementitious bond coat is to be applied. Otherwise, surface to remain dry and clean of debris and dust.

Step-5 **Thoroughly inspect all the concrete surfaces** prior to applications of adhesive and get approved from the Engineer-in-Charge.

Step-6 **Test the materials** by taking random samples and testing in approved laboratories so as to check whether they satisfy the physical and mechanical properties.

Step-7 **Make available at site** all necessary mechanical equipment as under :

a. Calibrated Spring Balance (for accurately weighing different components of materials in required proportions),

b. Mechanical blender for mixing

c. Spray equipment/brush for application of epoxy/ polymer modified/ bonding cement slurry

Step-8 **Bond Coat Mixing**: Components of the bonding coat mix shall be weigh batched and mixed in specified proportions in a clear container free from harmful residue or foreign particles. The components shall be thoroughly blended with a mechanical mixer to a uniform and homogeneous mixture. Small batches (upto 1 litre) may however be allowed by manual mixing using spatulas, palette, knives etc.

Step-9 **Bond coat application** for jacket concrete/ shotcrete/ Mortar placement:

The specified adhesive shall be applied to concrete surface at atmospheric temperatures below 40°C for epoxy adhesive and below 30°C for polymer modified cement or cement-sand slurry adhesive. Bonding coat shall be applied by spray equipment or stiff nylon bristle brush as approved by Engineer-in-Charge. The bonding material shall be worked well into the surface of the parent body ensuring that no pinholes are visible.

Polymer modified bonding cement slurry shall be applied to a thickness not in excess of 2 mm.

If necessary, a second coat shall be applied at right angles to the first to ensure complete coverage and absence of pin holes.

All concrete surface shall be well protected beyond limits of surface receiving adhesive against spillage.

Step-10 **Repair Material Application**: Fresh plastic concrete/ shotcrete/ mortar shall be applied while adhesive is still tacky and well within the pot-life/ setting period. If adhesive cures to the extent of loosing its tack or has set before

plastic concrete/shotcrete/mortar is placed, the same shall be removed or slightly abraded and second coat of adhesive applied.

Freshly placed plastic concrete shall be thoroughly consolidated to ensure full bonding of new concrete with the substrate.

Step-11 Bond of repair shall be tested in accordance with 1.4.1.3 given hereinafter.

1.4.1.3 Field Quality Performance Requirement:

Bond of repair with parent concrete

i) **Evaluate bonding** of fresh concrete/ shotcrete/ mortar to existing concrete after the fresh material has cured for not less than 7 days by sounding and tapping fresh concrete with a blunt metal instrument to the satisfaction of Engineer-in-charge. Suspect inadequate bonding, if a hollow sound is detected in any area. In case of conflicted location contractor shall extract one core from the repaired surface area at the end of 28 days.

ii) **Conduct one core test at random** for checking the bond, for every 100 square metre or part thereof. The contractor shall core each area after 28 days of application of concreting/ shortcreting/ repair mortar application for determination of bonding adequacy.

iii) **Core drilling shall be done through applied repair material** and into the existing concrete. Core diameter shall be not less than three times the nominal size of the coarse aggregate used in repair material or as required by the Engineer-in-Charge. Length of cylindrical cores shall preferably be twice the core diameter or twice the thickness of applied repair material or as instructed by Engineer-in-Charge but in any case not less than the dia of the core.

iv) **Cores shall be visually inspected** by Engineer-in-Charge for evidence of poor workmanship.

v) **Cores shall be tested in tension** to evaluate the quality of bond between new concrete/shotcrete/mortar and the parent concrete. If the failure is in the parent concrete the bond of new repair material shall be deemed to be satisfactory.

vi) **Failure at the bond line or in the repair material** shall be concluded as lack of proper bond or inadequate strength of repair mortar

vii) **Dismantle such areas of work** failed in bond or repair material and re-prepare the surface after chipping off new concrete/mortar work and abrading the epoxy/ polymer/cement slurry interface. Nothing for testing concrete for bond between old and new concrete shall be paid separately.

1.4.1.4 Measurements:

a) **Materials supplied**: The quantities of specified resin and hardener, polymers etc supplied shall be recorded after satisfying acceptability criteria. The solid contents of Acrylic/SBR polymer shall be determined in field laboratory or designated laboratory for each batch of supply of latex received and recorded separately batch wise for determining the solid contents for the purpose of payment.

The measurements of weight of the bonding materials supplied shall be weight of resin plus hardener for epoxy; solid contents of polymer for each batch of supply received;

b) **Materials Consumed**: Pre-measurements of the quantities of bonding materials (e.g. epoxy, Acrylic/SBR polymer) available or brought at site and the balance quantities remaining at the end of bonding coat application shall be recorded separately, which will determine the quantity of bonding materials actually consumed.

c) **Materials wasted:** The quantities of bond material wasted, discarded, hardened shall not count for payment and shall be recorded for deduction at the end of each operation.

For proper control so that the wastage is separately accounted, a register shall be maintained to get the cumulative quantity of material received as supply, consumed in the work, net balance in the store.

Bond Coat Application: The concrete surface, over which bond coat has been applied, shall be measured correct to a centimeter and area of surface worked out in square meters correct to second place of decimal.

Measurements shall be separately recorded for the supplies of material received, material consumed and area over which bond coat applied from time to time.

1.4.1.5 Rates:

The rates shall cover cost of all materials, labour and T&P involved in all the operations described above but shall not cover those involved in step 3 & 10.

Note : In respect of materials supplies, two stage payment shall be made. In the first stage 75 % of the rates quoted be released after the materials are brought to site of work and test results found satisfactory. Balance 25 % of the rates quoted shall be released in the second stage, which will be after their consumption in the work..

1.4.2 ALKALINE PASSIVATING BOND COAT OVER REINFORCEMENT:

PURPOSE: *To protect steel reinforcement with a passivating alkaline layer provided all around its circumference along the length with strong adhesive to bond with applied repair concrete or mortar.*

1.4.2.1 Materials and T&P:

Specified alkaline passivating & bonding materials e.g. CPCC material, epoxy, epoxy phenolic IPN-RB or specified polymer and cement, mixing water, necessary T&P for mixing and applying bond coat e.g. brush, mechanical mixer, mechanical stirrer, etc.

Product:

A) **Epoxy Adhesives** shall conform to ASTM C-882.

B) **Polymer Latex** shall conform to ASTM C-1059

C) **Cement** shall be ordinary Portland cement conforming to IS: 269

D) **Patented materials** e.g. CPCC or epoxy-phenolic IPN-RB as per licensee's specifications.

1.4.2.2 Execution:

Step-1 Follow the guidelines for Safety, Quality Assurance, Environmental Protection, Product delivery, Personnel, Supervision, Storage and Handling, etc given in Para 1.0.

Step-2 **Full quantity of manufactured repair materials shall be received** at site in factory sealed containers with labels legible and intact, if the shelf life so permits. Full quantity shall be worked out as theoretically required for consumption in the whole work .

Step-3 **Prepare the surface** for treatment (Refer Para 1.2.1, 1.2.2, 1.2.6 and 1.2.7 as may be applicable).

Step-4 **Thoroughly inspect all the concrete surfaces** prior to applications of passivating/bond coat and get approved from the Engineer-in-Charge.

Step-5 **Test the materials** by taking random samples and testing in approved laboratories so as to check whether they satisfy the physical and mechanical properties.

Step-6 **Make available at site** all necessary mechanical equipment as under :

a. Calibrated Spring Balance (for accurately weighing different components of materials in required proportions),
b. Mechanical blender for mixing
c. Brush for application of specified and approved passivating/bond coat.

Step-7 **Material Mixing**: Components of the passivating/ bond coat mix shall be weigh batched and mixed in specified proportions in a clear container free from harmful residue or foreign particles. The components shall be thoroughly blended with a mechanical mixer to a uniform and homogeneous mixture. Small batches (upto 1 litre) may however be allowed by manual mixing using spatulas, palette, knives etc.

Step-8 **Material Application**: The alkaline passivating & bonding material shall be applied to prepared reinforcement substrate after tying in new reinforcement wherever specified in the form of bars or welded wire fabric. It shall be applied to reinforcement surfaces by stiff nylon bristle brush. The coating material shall be worked well all round the periphery and along its exposed length using a stiff brush ensuring that no pinholes are remaining. The second coat, if required, the same shall be applied as per manufacturer's recommendation after the first coat is touch dry.

1.4.2.3 Measurements:

a) **Material supplied:** The quantities of specified resin and hardener, polymers, patented materials etc supplied shall be recorded after satisfying acceptability criteria. The solid contents of Acrylic/SBR polymer shall be determined in field laboratory or designated laboratory for each batch of supply of latex received and recorded separately batch wise for determining the solid contents for the purpose of payment.

The measurements of weight of the passivating and bonding materials supplied

shall be weight of resin plus hardener for epoxy; solid contents of polymer for each batch of supply received;

b) **Material Consumed:** Pre-measurements of the quantities of passivating and bonding materials (e.g. epoxy, Acrylic/SBR polymer/patented material) available or brought at site and the balance quantities remaining at the end of passivating & bonding coat application shall be recorded separately, which will determine the quantity of bonding materials actually consumed.

c) **Materials wasted:** The quantities of bond material wasted, discarded, hardened shall not count for payment and shall be recorded for deduction at the end of each operation.

For proper control so that the wastage is separately accounted, a register shall be maintained to get the cumulative quantity of material received as supply, consumed in the work and net balance in the store.

Passivating Coat Application: For the purpose of payment, the reinforcing bars coated with passivating and bond coat shall be grouped in two diawise categories, with one being upto and including 12 mm and the other above 12 mm. For each of such categories, length of bars coated all around, shall be separately measured. The length shall be measured in metres correct to second place of decimal

Measurements shall be separately recorded for the supplies of material received, actual quantity of material consumed from time to time.

1.4.2.4 Rates:

The rates shall cover cost of all materials, labour and T&P involved in all the operations described above except those involved in step-3.

Note : In respect of materials supplies, two stage payment shall be made. In the first stage 75 % of the rates quoted be released after the materials are brought to site of work and test results found satisfactory. Balance 25 % of the rates quoted shall be released in the second stage, which will be after their consumption in the work.

1.5 REPAIR ITEMS

1.5.1 SPECIFICATION FOR MICRO-CONCRETE:

PURPOSE: *A manufactured cementitious concrete mix for use in constricted locations, which is received in pre batched, prepackaged, single component dry mix of specified grade. When mixed with specified quantity of water, it is to have free flowing and self compacting characteristics in plastic state and on hardening it shall have non-shrink and impervious characteristics.*

1.5.1.1 Materials and T&P:

Specified grade of micro-concrete, mixing water, mechanical mixer, transportation and handling equipment, all necessary T&P for surface preparation, reinforcement bars, shear key bars, epoxy, power drilling equipment, props & supports, waterproof shuttering, specified passivating & bond coats for reinforcement and concrete, the ingredients as per design of concrete mix including super-plasticiser, micro-silica, other mineral admixtures to achieve concrete of specified grade and workability.

1.5.1.2 Procedure:

Step-1 **Follow the guidelines** for Safety, Quality Assurance, Environmental Protection, Product delivery, Personnel, Supervision, Storage and Handling, etc given in Para 1.0.

Step-2 **Full quantity of manufactured repair materials shall be received** at site in factory sealed containers with labels legible and intact provided that the shelf life so permits. Otherwise substantial quantity as could be consumed within the shelf life shall be received as per quantity approved by Engineer-in-Charge. Full quantity shall be worked out as theoretically required for consumption in the whole work.

Step-3 **Testing of Material:** The requisite number of test specimens of micro-concrete shall be cast from each batch of manufacture or supply received (whichever is less) for these to be tested for conformance to the specified requirements of 7 and 28-day cube crushing strength, surface absorption of water, permissible limits of shrinkage, etc before use on the work.

Step-4 **Surface Preparation:** The appropriate surface preparation and crack sealing as per site requirements shall be completed, which may sequentially cover one or more of the following items of work:

a) Prop & support the structural member to relieve it of stress and strains (Refer Para 1.1.1)

b) Removal of existing surface plaster shall be done according to Para 1.2.1.

c) Chipping unsound/weak concrete material shall be done according to Para 1.2.2.

d) Removing concrete all around embedded rusted reinforcement shall be done according to Para 1.2.6.

e) Removing and cleaning reinforcement of rust from its surface to give it a shining bright metal shall be done according to Para 1.2.7.

f) Sealing the cracked or honeycombed concrete with injection grouting shall be done according to Para 1.3.1 and 1.3.2

g) Providing and inserting mild steel shear keys shall be done according to Para 1.2.9.

h) Cleaning of lightly sticking materials and foreign matter from the exposed concrete surface and steel reinforcement by suitable means shall be done according to Para 1.2.10.

Step-5: **Additional reinforcement, if required,** shall be tied with required overlaps or welded. (Refer Para No 1.5.5).

Step-6 **Apply Passivating & bonding** coat over the cleaned reinforcement according to Para 1.4.2.

Step-7 **Apply bond coat** on the cleaned concrete substrate according to Para 1.4.1.

Step-8 **Erect pre-fabricated watertight shuttering**, if required, while the bond coat is still tacky according to Para 1.1.2 to receive the self compacting free flowing

micro concrete

Step-9 **Prepare self compacting, free flowing micro-concrete** simultaneously along with step-8 so as to have a uniform consistency and texture in a mechanical concrete mixer by adding a specified proportion of water in the preweighed dry mix of pre-batched, prepackaged, single component micro concrete .

Step-10 **Pour the fresh micro-concrete** in the shuttering mould or over the surface prepared to receive it, while the bond coat is still tacky.

Step-11 **Wet cure the micro-concrete** according to Para 1.6.1

Step-12 **Field Quality Performance** shall be culculated as per Para 1.4.13

1.5.1.3 Measurements:

After surface preparation, if necessary for working out volume of applied repair material, pre-measurements of dimensions of the substrate shall be recorded. For the purpose of payment, measurements of the finished surface shall be recorded only after wet curing is done and surface evaluated satisfactorily. The dimensions shall be recorded correct to a centimeter and volume shall be worked out in cubic metres correct to second place of decimal.

1.5.1.4 Rates:

The rates shall cover cost of all materials, labour and T&P involved in all the operations described above except for those involved in steps 4, 5, 6, 7, 8 and 11.

Note : In respect of materials supplies, two stage payment shall be made. In the first stage 75 % of the rates quoted be released after the materials are brought to site of work and tested satisfactorily. Balance 25 % of the rates quoted shall be released in the second stage, which will be after their consumption in the work.

1.5.2 SPECIFICATION FOR SHOTCRETE:

PURPOSE: *Application of repair concrete of specified mix proportions by spraying it under pressure in layers over prepared substrate.*

1.5.2.1 Materials and T&P:

1.5.2.1.1 Materials:

Cement:

The cement shall be ordinary Portland cement of 43 grade conforming to relevant B.I.S. Code of Practice.

Aggregates:

Sand for shotcrete shall comply with the requirements given in IS 383 and graded evenly from fine to coarse as per Zone-II and Zone III grading. Sand failing to satisfy this grading may, however, be used only if pre-construction testing establishes that it gives good results.

Coarse aggregate when used shall comply with the requirements of IS 383. It shall, generally conform to the grading given below:

GRADING OF COARSE AGGREGATES

IS Sieve Designation, mm	Percentage Passing by mass for aggregate of nominal maximum size
10	100
4.75	10-30
2.36	0-10
1.18	0-5

All over sized pieces of aggregate shall be rejected by screening.

Gradation of the combined coarse and fine aggregate mixture used for shotcrete shall generally lie between the following limits.

I.s.sieve	Percent passing by Weight Gradation
10 mm	100 -100
4.75 mm	72- 85
2.36 mm	52-73
1.18 mm	36-55
600 microns	28-38
300 microns	7-20
150 microns	0-8

Water

Water used for shotcrete shall conform to the requirement of I.S. 456-2000

Admixture

Admixture shall only be used if approved by the Engineer-in-Charge who shall be furnished with all required literature pertaining to its efficacy. Guniting admixtures & quick setting agents may be used to minimise the rebound loss and increase the bond & enable thicker layers per coat. The admixture shall meet the requirement of I.S. 456 and I.S. 9103 .

Reinforcement

Reinforcement bars if used shall conform to I.S. 432 (Part-I) or I.S. 1786. Welded wire fabric where used shall conform to I.S. 1566.

Concrete

The grade of concrete shall be as specified i.e. the characteristic compressive strength of 15 cm cube at 28 days should be as specified. The water cement ratio for shotcrete shall be within the range 0.45- 0.50 by mass.

1.5.2.1.2 Equipment

For Dry mix process:

Batching and mixing equipment- Batching shall be done by mass. The moisture content of the sand shall be such that the sand cement mixture will flow at a uniform rate through the delivery hose. The sand shall be moistened or dried as required to bring the moisture content to a satisfactory level. Fluctuations in moisture content shall be avoided.

The mixing equipment shall be capable of thoroughly mixing the sand and cement in sufficient quantity to maintain continuity of placing. The mixing time shall be not less than 1 minute in a drum type mixer, where other mixers are proposed, satisfactory evidence shall be presented to the Engineer-in-Charge that they are capable of thorough mixing. The mixer shall be self cleaning capable of discharging all mix material without any carry over from one batch to the next. It shall be inspected and thoroughly cleaned at least once in a day and more often if instructed by Engineer-in-Charge to prevent accumulations of batched material.

Delivery equipment or guniting equipment- The delivery equipment shall comply with requirements given in I.S. 6433.

Air Supply - The compressor shall be fitted with a moisture extractor to keep up a supply of clean, dry air adequate for maintaining a sufficient nozzle velocity for all parts of the work while simultaneously operating a blow pipe for clearing away re-bound material.

A gauge near the material outlet of the gun shall measure the operating pressure. The air pressure shall be uniformly steady (non pulsating).

For lengths of hose upto 30m, air pressure at the gun shall be 0.3 N/Sq.mm or more. Where length exceeds 30m the pressure shall be increased by 0.035 N/Sq.mm for each additional 15 m of hose required & by 0.035 N/sq.mm for each 7.5 M that the nozzle is raised above the gun.

Water supply -The water pressure at the discharge nozzle shall be sufficiently greater than the operating air pressure to ensure that the water is intimately mixed with the other materials. If the line water pressure is inadequate, a water pump shall be introduced into the line. The water pressure shall be uniformly steady (non pulsating).

1.5.2.2 Procedure:

Step-1 **Follow the guidelines** for Safety, Quality Assurance, Environmental Protection, Product delivery, Personnel, Supervision, Storage and Handling, etc given in Para 1.0.

Step-2 **Full quantity of manufactured repair materials shall be received** at site in factory sealed containers with labels legible and intact provided that the shelf life so permits. Otherwise substantial quantity as could be consumed within the storage period shall be received as per quantity approved by Engineer-in-Charge. Full quantity shall be worked out as theoretically required for consumption in the whole work.

Step-3 **Mix Design**: The shotcrete mix design shall be developed by laboratory tests and field trials and got approved from Engineer-in-charge.

Step-4 **Pre-construction testing**- A laboratory trial and testing shall be carried out prior to the commencement of the work in order to check the operation of the

equipment, the skill of the operating staff and also to verify that the specified quality of shotcrete would be expected in the structure. The procedure for pre-construction testing shall be as below;

A. The operating staff, using the equipment, materials and mix proportions proposed for the job, shall fabricate test panels simulating actual job conditions.

B. For the dry mix process, the amount of water added at the nozzle shall be adjusted so that in place shotcrete shall be adequately compacted and will neither sag nor show excessive rebound. At least, two mixes shall be tested before deciding on the final mix proportion.

C. The panels shall be fabricated by gunning on to a back form of plywood. A separate panel shall be fabricated for each gunning position to be encountered in the structure. At least part of the panel shall contain the same reinforcement as the structure to show whether sound shotcrete is obtained behind the reinforcing rods. The panel shall be large enough to obtain all the tests specimen needed, and also to indicate quality and uniformity that may be expected in the structure. Generally the size of panel shall be not less than 75cm x 75 cm. The thickness shall be the same as in the structure except that it shall be not less than 50mm.

D. Cores shall be taken from the panels for testing. The cores shall preferably have a diameter of 7.5 cm but not less than 50 mm and a length to diameter ratio of at least 1. The specimen shall be tested in compression at the age of 7 or 28 days or both as directed by Engineer-in-Charge. The result of the tests shall be compared with the cube strength taken earlier. Nothing extra shall be paid for core testing of concrete for pre construction testing.

E. The cut surface of the specimen shall be carefully examined and additional surfaces shall be exposed by sawing or breaking the panel, if it is considered necessary by Engineer-in-Charge to check soundness and uniformity of the material. All cut and broken surfaces shall be dense and free from laminations and sand pockets.

Step-5 **Surface Preparation:** The appropriate surface preparation and crack sealing as per site requirements shall be completed, which may sequentially cover one or more of the following items of work:

a) Prop & support the structural member to relieve it of stress and strains (Refer Para 1.1.1)
b) Scaffolding & working platforms for the exterior members (Refer Para 1.1.3), if not already done and if necessary, shall be erected for working upon the area.
c) Working Platforms for interior members, if not already done and if necessary, shall be erected suitably or provided as mobile.
d) Provide Protective Screen (Refer Para 1.1.8), if not already done and if necessary.
e) Removal of existing surface plaster (Refer Para no 1.2.1)

f) Chipping unsound/weak concrete material (Refer Para no 1.2.2). However, no square shoulders shall be left at the perimeter of the cavity, all edges shall be tapered. The final cut surface shall be critically examined to make sure that it is sound and properly shaped.

g) Removing concrete all around embedded rusted reinforcement (Refer Para no1.2.6).

h) Removing and cleaning reinforcement of rust from its surface to give it a shining bright metal (Refer Para no 1.2.7).

i) Sealing the cracked or honeycombed concrete with injection grouting (Refer Para no 1.3.1 and 1.3.2),

j) Providing and inserting mild steel shear keys, also to act as depth gauge for controlling thickness of gunite/shotcrete

k) Cleaning of lightly sticking materials and foreign matter from the exposed concrete surface and steel reinforcement by suitable means followed by an oil free dry air blast

Step-6 **Additional reinforcement, if required, and welded wire fabric** shall be tied with required overlaps or welded. (Refer Para No 1.5.5).

Step-7 **Adequate and safe working platform,** as approved as per Para 1.1.3, shall be provided so that the gunite/shotcrete operator can hold the nozzle at optimum angle and distance from the surface for all parts of work.

Step-8 **Suitable formwork** of plywood sheeting or other suitable material shall be fixed true to lines and dimension to get finished sides and edges of the gunited/ shotcreted surface. Refer Specifications of form work (centering and shuttering)' contained in Para 5.2 of CPWD Specifications 1996 (Vol-II).

They shall be adequately braced to protect against excessive vibration and shall be constructed so as to permit the escape of air and rebound during the gunning operation. Forms shall be oiled or dampened and they shall be cleaned just before gunning.

Formwork shall be necessarily required for first stage application of shotcrete/ gunite on two opposite faces of rectangular columns and beams, whereas in second stage of application of repair material on the remaining faces, gunited/ shotcreted surface at edges/corners shall serve the purpose without requiring further formwork.

The minimum clearance between the reinforcement and the formwork or other back up material shall be provided as per detailed drawing.

Step-9 **Alignment & thickness Control-** Adequate ground wires shall be installed to establish thickness and surface planes of the shotcrete build up. Both horizontal and vertical ground wires shall be installed at the corners and offsets not clearly fixed by the formwork, i.e. at exterior corners of columns and beams and other such locations. Ground wires shall be tight and true to line and placed in such a manner that they may be further tightened.

Step-10 **Passivating/bond coat** shall be applied to the reinforcement and the welded

wire fabric

Step-11 **Bond coat** over the prepared concrete and reinforcement substrate as above shall be applied

Step-12 **Gunite/Shotcrete Application:** Fresh gunite/shotcrete shall be applied at the earliest possible, when bond coat, as applied in Step-11 above, is still tacky.

Maximum thickness to be applied in one pass will be, in general, limited to 25 mm for overhead application and 50 mm on sides. Where gunite is to be placed to a thickness of more than 50 mm on sides or 25 mm overhead, it is preferable for it to be built up in more than one application.

Each layer of shotcrete shall be built-up by making several passes or loops of the nozzle over the working area. This will be done by moving the nozzle rythmetically in series of loops from side to side and up and down. The shotcrete shall emerge from the nozzle in a steady, uninterrupted flow. If the flow becomes intermittent due to any cause, the Operator shall direct it away from the work until it again becomes constant. The distance of nozzle from work (usually between 0.5 and 1.5 m) shall be such as to give the best results for the working conditions. The nozzle shall be held perpendicular to the surface of application. However, when gunning through and encasing reinforcing bars the nozzle shall be held closer and at a slight angle to the perpendicular. Also the mix shall be little wetter than normal but not so wet as to cause sloughing behind the bars.

Application shall begin at the bottom for columns and beams and for slabs, the nozzle shall be held at a slight angle to the perpendicular so that the rebound is blown on to complete portion from where it shall be removed.

Embed reinforcement atleast adjacent to the form in the first layer completely. The thickness of layers shall be adjusted so that shotcrete does not sag. Where thick layers are applied, top surface shall be maintained at a 45 degree slope.

Rebound material, ricocheting off the surface, shall not be worked back into the construction. If it does not fall clear of the work, it shall be removed. Rebound shall not be salvaged and included in later batches.

Theoretical consumption of cement - For working out the theoretical consumption of cement in shotcreting, following coefficients shall be added for accounting for the concrete wasted as loss due to rebound in various items.

1. Ceiling of RCC slab - 40%
2. Vertical faces of R.C.C. beams columns & R.C.C. walls
   a. with face width not exceeding 450 mm - 50%
   b. with face width exceeding 450 mm - 45%

Construction joints- Construction joints shall generally be tapered to a thin edge over a width of 300 mm. However, in case of joints, which in the opinion of the Engineer-in-Charge, are likely to be subjected to compressive stresses,

square joints shall be provided by temporarily fixing the batten formwork of required thickness. In case of square joints, steps shall be taken by the Contractor to avoid or remove trapped rebound in the joint. The entire joint shall be thoroughly cleaned and the approved bonding coat applied prior to the application of additional shotcrete.

Preparation for succeeding layers- When a layer of shotcrete is to be covered by a succeeding layer, it shall first be allowed to take its initial set. Then all laitance, loose materials and rebound shall be removed by brooming. Any laitance that has attained final set shall be removed by sand blasting and the surface cleaned with an air jet. In addition the surface shall be thoroughly sounded with a hammer for drummy areas, sags or any other defects, which shall be carefully cut out and replaced with succeeding layer as instructed by Engineer-in-Charge. Succeeding layers shall be shot within 4 to 8 hours to attain the required thickness. In case application of succeeding layer is delayed beyond 24 hours, then the bond coat shall be applied at the interface for which no extra payment shall be made to the contractor.(Refer Para No 1.4.1).

Suspension of work: The application of shotcrete shall be suspended in condition of likely exposure to high winds, freezing or rain.

At the end of each day of work, or on stopping work for any other reason, the shotcrete shall be sloped off to a thin edge and then the work shall be resumed on next day after cleaning the surface of joint and applying a bond coat of approved formulation.

Inspection- The shotcreting shall be continuously inspected by a qualified supervisor, who shall check material, forms, reinforcement, ground wires, delivery equipment, application of material, curing, protection against high or low temperatures. Each layer of concrete shall be systematically sounded with a hammer to check for drummy areas.

Permissible Tolerances: The permissible tolerance on the thickness of work executed by shotcrete shall be (-) 3 mm to (+) 8 mm.

Quality control: Small un-reinforced test panels, at least 30 cm square and 75 mm thick shall be periodically gunned, and cores shall be extracted and compressive tests shall be performed periodically in the same manner as at step-4 above. The frequency of samples shall be one sample for every 10 cum of gunite/shotcrete.

In addition, concrete cubes prepared by directly gunning into 15 cm cube mould, shall also be used for day-to-day quality control tests. One sample comprising of three test specimens for testing at 28 days, shall be taken for every 5.0 cubic metre of concrete. Additional cubes if instructed by Engineer-in-Charge shall also be taken for each sample to determine the strength of gunite/ shotcrete at seven days.

All the specimen shall be tested as described in IS 516.

The gunite shall be deemed to comply with the strength requirements if the test results satisfies the acceptance criteria as per IS 456

Step-13 Wet cure the shotcreted/gunited surface (Refer 1.6.1).

Step-14 F**ield Quality Performance** shall be evaluated as per Para 1**.4.1.3:**

1.5.2.3 Measurements

Shotcreting upto 50 mm thickness shall be measured in square metre of finished surface area.

1.5.2.4 Rates:

Rate includes cost of all T & P material, labour and T&P involved in all the operations described above except specifically mentioned and those involved in steps 5, 6, 8, 10, 11 and 13.

Note : In respect of materials supplies, two stage payment shall be made. In the first stage 75 % of the rates quoted be released after the materials are brought to site of work and tested satisfactorily. Balance 25 % of the rates quoted shall be released in the second stage, which will be after their consumption in the work.

1.5.3 PLAIN/REINFORCED CONCRETE JACKET FOR THE STRUCTURAL MEMBERS e.g. COLUMNS, PILLARS, PIERS, BEAMS ETC.):

PURPOSE: *To provide a thin walled RCC element structurally bonded to the substrate of an existing stress-relieved structural member either to increase its structural size & strength or to restore the reduced structural size due to chipping.*

1.5.3.1 Materials and T&P:

All necessary T&P for surface preparation, mechanical mixer, transportation and handling equipment, reinforcement bars, shear key bars, epoxy, power drilling equipment, props & supports, waterproof shuttering, specified passivating & bond coats for reinforcement and concrete, mixing water, the ingredients as per design of concrete mix including super-plasticiser, micro-silica, other mineral admixtures to achieve concrete of specified grade and workability.

1.5.3.2 Procedure:

Step-1 **Follow the guidelines** for Safety, Quality Assurance, Environmental Protection, Product delivery, Personnel, Supervision, Storage and Handling, etc given in Para 1.0.

Step-2 **Full quantity of manufactured repair materials shall be received** at site in factory sealed containers with labels legible and intact provided that the shelf life so permits. Otherwise substantial quantity as could be consumed within the shelf life shall be received as per quantity approved by Engineer-in-Charge. Full quantity shall be worked out as theoretically required for consumption in the whole work.

Step-3 **Testing of Material:** The requisite number of test specimens of concrete shall be cast from each batch of manufactured or supplied materials received (whichever is less) for these to be tested for conformance to the specified requirements of 7 and 28-day cube crushing strength, surface absorption of water, permissible limits of shrinkage, etc before use on the work.

Step-4 **Surface Preparation:** The appropriate propping, surface preparation and crack sealing as per site requirements shall be completed, which may sequentially cover one or more of the following items of work:

a) Prop & support the structural member to relieve it of stress and strains (Refer Para 1.1.1)

b) Removal of existing surface plaster shall be done according to Para 1.2.1.

c) Chipping unsound/weak concrete material shall be done according to Para 1.2.2.

d) Removing concrete all around embedded rusted reinforcement shall be done according to Para 1.2.6.

e) Removing rust scales and cleaning reinforcement of rust from its surface to give it a shining bright metal shall be done according to Para 1.2.7.

f) Sealing the cracked or honeycombed concrete with injection grouting shall be done according to Para 1.3.1 and 1.3.2

g) Providing and inserting mild steel shear keys shall be done according to Para 1.2.9.

h) Additional reinforcement, if required, shall be tied with required overlaps or welded. (Refer Para No 1.5.5).

i) Cleaning of lightly sticking materials and foreign matter from the exposed concrete surface and steel reinforcement by suitable means shall be done according to Para 1.2.10.

Step-5 **Drill holes in RCC Slabs of appropriate** diameter at appropriate locations for pouring concrete in the jacket close to beam and slab soffits.

Step-6 **Apply Passivating & bonding** coat over the reinforcement according to Para 1.4.2.

Step-7 **Apply bond coat** on the cleaned concrete substrate according to Para 1.4.1.

Step-8 **Fabricate and erect watertight shuttering**, if required, while the bond coat is still tacky according to Para 1.1.2 to receive the self compacting free flow concrete

Step-9 **The specified concrete (self compacting and free flow) shall be prepared, poured and compacted** well within the tacky period of bond coat. The CPWD specifications for manufacture and placing of concrete shall generally be followed.

Step-10 **Wet cure the concrete** jacket according to Para 1.6.1

Step-11 **Test the Surface** of 7-day cured concrete for soundness.

Step-12 **Field Quality Performance** shall be evaluated as per Para **1.4.1.3:**

1.5.3.3 Measurements:

Dimensions of area of finished surface shall measured correct to a centimeter and area

worked out in square metres correct to second place of decimal for payment purposes.

1.5.3.4 Rates:

The rates shall cover cost of all materials, labour and T&P involved in all the operations described above except for those involved in steps 4, 5, 6, 7, 8 and 10.

Note : In respect of materials supplies, two stage payment shall be made. In the first stage 75 % of the rates quoted be released after the materials are brought to site of work and tested satisfactorily. Balance 25 % of the rates quoted shall be released in the second stage, which will be after their consumption in the work.

1.5.4 PROVIDING AND LAYING AN OVERLAY OF REINFORCED CONCRETE OVER PREPARED SURFACE OF EXISTING RCC SLAB/BEAM ETC. :

PURPOSE: *To provide specified additional thickness of RCC over an existing stress-relieved RCC slab/beam, bonded structurally to the substrate either to increase the structural thickness and/or additional reinforcement to enhance the load carrying capacity or to restore the reduced thickness of RCC slab due to removed weak and/or carbonated concrete.*

1.5.4.1 Materials and T&P:

All necessary T&P for surface preparation, reinforcement bars, shear key bars, epoxy, power drilling equipment, props & supports, specified passivating & bond coats for reinforcement and concrete, mechanical mixer, transportation and handling equipment, the ingredients as per design of concrete mix including mixing water, super-plasticiser, micro-silica, other mineral admixtures to achieve concrete of specified grade and workability.

1.5.4.2 Procedure

Step-1 **Follow the guidelines** for Safety, Quality Assurance, Environmental Protection, Product delivery, Personnel, Supervision, Storage and Handling, etc given in Para 1.0.

Step-2 **Full quantity of manufactured repair materials shall be received** at site in factory sealed containers with labels legible and intact provided that the shelf life so permits. Otherwise substantial quantity as could be consumed within the self life shall be received as per quantity approved by Engineer-in-Charge. Full quantity shall be worked out as theoretically required for consumption in the whole work.

Step-3 **Testing of Material:** The requisite number of test specimens of concrete shall be cast from each batch of manufactured or supplied materials received (whichever is less) for these to be tested for conformance to the specified requirements of 7 and 28-day cube crushing strength, surface absorption of water, permissible limits of shrinkage, etc before use on the work.

Step-4 **Mark the area of overlay** over the RCC slab/beam.

Step-5 **Surface Preparation:** The appropriate propping/supporting, surface preparation and crack sealing as per site requirements shall be completed, which may sequentially

cover one or more of the following items of work:

a) Prop & support the structural member to relieve it of stress and strains (Refer Para 1.1.1)
b) Removal of existing surface plaster/treatment shall be done according to Para 1.2.1 or 1.2.3 as the case may be.
c) Chipping unsound/weak concrete material shall be done according to Para 1.2.2.
d) Removing concrete all around embedded rusted reinforcement shall be done according to Para 1.2.6.
e) Removing and cleaning reinforcement of rust from its surface to give it a shining bright metal shall be done according to Para 1.2.7.
f) Sealing the cracked or honeycombed concrete with injection grouting shall be done according to Para 1.3.1 and 1.3.2
g) Providing and inserting mild steel shear key bars shall be done with minimum 3 nos per square meter of surface area of substrate according to Para 1.2.9, which may also be used as depth measuring gauge.
h) Additional reinforcement, if required, shall be tied with required overlaps or welded. (Refer Para No 1.5.5).
i) The rust, if any, persisting over the existing exposed reinforcement or the new reinforcement shall be removed mechanically or chemically, as per Para no 1.2.7
j) Cleaning of lightly sticking materials and foreign matter from the exposed concrete surface and steel reinforcement by suitable means shall be done according to Para 1.2.10
k) Provide shuttering along sides of overlay as per Para 5.2 of CPWD Specifications 1996Vol-II.

Step-6 **Clean the dust from the prepared surface** of concrete and reinforcement wth a clean oil free air blast.

Step-7 **Alignment & thickness Control**- Ground wires shall be fixed at reference points to measure and control the thickness of overlay. Shear keys fixed earlier could also function as depth gauges. Adequate ground wires shall be installed to establish thickness and surface planes of the overlay build up. Ground wires shall be tight and true to line and placed in such a manner that they may be further tightened.

Step-8 **Apply Passivating & bonding** coat over the existing and new reinforcement according to Para 1.4.2.

Step-9 **Apply bond coat** on the concrete substrate according to Para 1.4.1.

Step-10 **Prepare self compacting, free flowing concrete for overlay** as per design mix so as to have a uniform consistency and texture in a mechanical concrete mixer by adding a specified proportion of water to the weigh batched ingredients of the design mix including necessary super plasticisers.

Step-11 **Pour the fresh concrete** over the surface prepared to receive it, while the bond coat is still tacky.

Step-12 **Wet cure the concrete overlay** according to Para 1.6.1

Step-13 **Test the Surface** of 7-day cured concrete overlay for soundness by tapping or sounding with hard blunt surface.

1.5.4.3 Measurements:

Length and width of the specified thickness of overlay concrete shall be measured correct to a centimeter and area worked out in square metres correct to second place of decimal. This item shall be measured only after proper wet curing has been done and surface has been satisfactorily .

1.5.4.4 Rates:

The rates shall cover cost of all materials, labour and T&P involved in all the operations described above except for those involved in step nos 5, 8, 9 and 12.

Note : In respect of materials supplies, two stage payment shall be made. In the first stage 75 % of the rates quoted be released after the materials are brought to site of work and tested satisfactorily. Balance 25 % of the rates quoted shall be released in the second stage, which will be after their consumption in the work.

1.5.5 REINFORCEMENT FOR RCC WORK ETC. :

PURPOSE: *To provide reinforcement in repair concrete for structural purposes, controlling effects of thermal variation or holding shotcrete/gunite material in position. The reinforcement material may comprise specified grade and quality with or without zinc coating.*

1.5.5.1 Material & T&P:

Specified reinforcing material, necessary hand or power driven tools for cutting, bending, binding, transportation, handling and placement, etc Reinforcement bars if used shall conform to I.S. 432 (Part-I) or I.S. 1786. Welded wire fabric where used shall conform to I.S. 1566.

1.5.5.2 Procedure:

The general requirements, placing in position, measurement etc. shall be generally followed as in Para 5.3 of CPWD specifications 1996 Vol-II excepting those specifications provided in the following clauses.

Step-1 **Follow the guidelines** for Safety, Quality Assurance, Environmental Protection, Product delivery, Personnel, Supervision, Storage and Handling, etc given in Para 1.0.

Step-2 **Testing of Material:** The requisite number of test specimens of specified reinforcing material shall be collected from each batch of manufacture or supply received (whichever is less) for these to be tested for conformance to the specified requirements before use on the work.

Step-3 **Execution**:

The required reinforcement as per detailed drawings in the form of round bars or

welded wire fabric in such a way so as to cause the least interference with placement of repair material.

Overlaps: Lapped reinforcing bars shall not be tied together. They shall be separated by at least 50 mm wherever possible. Wire mesh shall be lapped by 1-1/2 squares in all direction. Minimum requirement of lap length of bars shall be as specified in I.S. 456.

Clearance around reinforcement: Sufficient clearance shall be provided around the existing exposed and additional reinforcement to permit complete encasement with sound repair material.

Cover: Minimum cover to reinforcement shall be as per I.S. 456. As far as possible the bars shall be arranged so as to permit shooting from opposite side.

Fixing: Reinforcement shall be fixed to existing shear key bars and depth gauges driven into the concrete with wires and secured rigidly so that the vibration resulting from the deposition of repair material shall not impair or displace them.

Where gunite /shotcrete to be done in more than one layer: In such cases, the additional reinforcement should be so fixed that it is encased in succeeding layer. No additional reinforcement is required to be fixed in first layer of gunite.

Mesh reinforcement shall be fixed in the manner so that it is firmly held at least 12 mm away from the parent concrete surface as well as from the final finished surface. It shall be ensured that it is stiffened enough and cannot belly out during the guniting / jacketing / concrete overlays with consequent lack of cover. It shall be done by tying with parent concrete surface through shear key bars or depth gauges. GI-wire mesh fabric will add sacrificial "Zinc" coating & shall reduce corrosion process in the reinforcement. The wire mesh spacing shall be as specified in the drawings.

1.5.5.3 Measurements:

For the purpose of measurement for payment, length of specified reinforcing bars/ wires shall be measured correct to a centimeter and that of wire fabric, length and width shall be measured correct to a centimeter to work out area in square metres correct to second place of decimal. Overlaps shall be accounted for in the length/area measurements.

For each batch of supply of steel reinforcement or the wire fabric, weight coefficients shall be worked out per meter length for bars and wires and per square meter for wire fabric. The weight coefficients shall be calculated correct to third place of decimal in each batch by weighing three randomly taken samples from the lot of supply and taking an arithmetical mean of the weights per unit length/area.The total weight shall be worked out in Kilograms correct to second place of decimal

1.5.5.4 Rates:

Rates shall cover the costs of all labour, material and T&P involved in all operations

detailed above.

Note : In respect of materials supplies, two stage payment shall be made. In the first stage 75 % of the rates quoted be released after the materials are brought to site of work and tested satisfactorily. Balance 25 % of the rates quoted shall be released in the second stage, which will be after their consumption in the work.

1.5.6 PROVIDING STRUCTURAL CONNECTION:

PURPOSE*: To establish a structural connection for a new RCC member to be connected with the existing structural member for transfer of the end forces between the members.*

1.5.6.1 Specifications:

This item is a combination of various other items of work, specifications of which are distinctly given under relevant items. Hence no separate specification of materials, T&P, execution procedure is being given.

1.5.6.2 Measurements:

The Cross-sectional area at the interface of the structural connections shall be measured and area shall be worked out in square metres correct to second place of decimal.

1.5.6.3 Rates:

Rates shall cover all incidental cost of labour, material and T&P involved in all operations other than those items of work distinctly mentioned in the nomenclature payable separately.

1.5.7 CEMENT BASED POLYMER MODIFIED MORTAR :

PURPOSE: *To carry out structural repairs to prepared patches of spalled concrete with an alkaline impervious repair material comprised of polymer admixed cement-sand mortar.*

1.5.7.1 Materials and T&P:

Polymers in emulsion or powder forms as may be specified conforming to ASTM C-1059, Ordinary Portland Cement of 43 grade conforming to relevant BIS code, Sand conforming to Zone-II or Zone-III grade of IS: 383, Mixing water conforming to IS: 456-2000, mortar mixer with mechanical water dozer, spatulas, trowels, etc.

1.5.7.2 Procedure:

Step-1 **Follow the guidelines** for Safety, Quality Assurance, Environmental Protection, Product delivery, Personnel, Supervision, Storage and Handling, etc given in Para 1.0.

Step-2 **Full quantity of specified polymers shall be received** at site in factory sealed containers with labels legible and intact provided that the shelf life so permits. Otherwise substantial quantity as could be consumed within the shelf life shall be received as per quantity approved by Engineer-in-Charge. Full quantity shall be worked out as theoretically required for consumption in the whole

work.

Step-3 **Testing of Material:** The requisite number of test specimens of mortar shall be cast from each batch of manufactured or supplied materials received (whichever is less). These are to be tested for conformance to the specified requirements contained in Table 5.5 before use on the work. Polymer modified cement mortar with cement: sand proportion by weight as (1:3) shall have the following properties

Minimum compressive strength - 20N/sq.mm after 28 days at 27°C
Minimum tensile strength - 6.5 N/sq.mm after 28 days at 27°C

Step-4 **Identify and mark the area** for Polymer modified mortar repair.

Step-5 **Surface Preparation:** The appropriate propping/supporting, surface preparation and crack sealing as per site requirements shall be completed, which may sequentially cover one or more of the following items of work:

a) Prop & support the structural member to relieve it of stress and strains (Refer Para 1.1.1)
b) Removal of existing surface plaster/treatment shall be done according to Para 1.2.1 or 1.2.3 as the case may be.
c) Chipping unsound/weak concrete material shall be done according to Para 1.2.2.
d) Removing concrete all around embedded rusted reinforcement shall be done according to Para 1.2.6.
e) Removing and cleaning reinforcement of rust from its surface to give it a shining bright metal shall be done according to Para 1.2.7.
f) Sealing the cracked or honeycombed concrete with injection grouting shall be done according to Para 1.3.1 and 1.3.2
g) Providing and inserting mild steel shear key bars shall be done with minimum 3 nos per square meter of surface area of substrate according to Para 1.2.9, which may also be used as depth measuring gauge.
h) Additional fresh reinforcement, if required, shall be tied with required overlaps or welded.
i) The rust, if any, persisting over the existing exposed reinforcement or the new reinforcement shall be removed mechanically or chemically, as per Para no 1.2.7
j) Cleaning of lightly sticking materials and foreign matter from the exposed concrete surface and steel reinforcement by suitable means shall be done according to Para 1.2.10

Step-6 **Clean the dust and saturate the prepared surface** of concrete and reinforcement with a clean oil free air blast and water fit for construction.

Step-7 **Inspection of concrete surface** prior to adhesive application shall be thoroughly inspected and got approved by the Engineer-in-Charge. Surfaces shall be ensured to be free from any deleterious materials such as oil, dust, dirt etc. using oil free air blast.

Step-8 **Alignment & thickness Control-** Ground wires shall be fixed at reference points to measure and control the thickness of overlay. Shear keys fixed earlier could also function as depth gauges. Adequate ground wires shall be installed to establish thickness and surface planes of the overlay build up. Ground wires shall be tight and true to line and placed in such a manner that they may be further tightened.

Step-9 **Apply Passivating & bonding** coat over the cleaned existing and new reinforcement according to Para 1.4.2.

Step-10 **Apply bond coat** on the cleaned concrete substrate according to Para 1.4.1.

Step-11 **Mix and Prepare Polymer Modified Mortar** to have a uniform consistency and texture by adding cement sand and polymer as weigh batched ingredients of the design mix, a specified proportion of water through water dozer.

Use of prepacked ready to use components supplied by manufacturers in containers may be allowed subject to approval of Engineer-in-Charge. In case where prepacked ready to use materials are to be used, the contractor shall submit the manufacturer's certificate verifying conformance to material specification as specified, manufacturer's mixing and application procedure for approval by Engineer-in-charge.

Plastering with cement based polymer modified mortar shall be done immediately after applying the bonding slurry to the prepared surfaces, preferably in coats of approximately 10mm thickness with thickness of trowelling not to exceed the range given in Table 5.6 as greater thickness may lead to delamination/collapse. However, coats shall be applied in fairly rapid successions within 15 to 30 minutes. After applications of mortar the surface shall be finished using a wooden float.

. Step-12 **Moist cure the polymer modified mortar** surface for 1-3 days followed by air curing at ambient temperature or as per manufacturer's specification, if specified otherwise. Use of flowing water or ponding of water shall not be done for curing. Steam curing shall not be permitted.

Step-13 **Test the Surface** of 7-day cured concrete overlay for soundness by tapping or sounding with hard blunt surface.

1.5.7.3 Inspection & Quality control:

The mortar application work shall be continuously inspected by a qualified supervisor who shall check materials, application of mortar, curing stoppage of work during low temperatures (minimum working temperature being 8^0C in most of the polymer modified mortar or as per manufacturer direction) and high winds etc. Each completed work of mortar shall be systematically sounded with a hammer to check for drummy areas after hardening.

In suspect areas or whenever directed by Engineer-in-Charge, the contractor shall drill the cores from the finished work and in to the host concrete after 28 days of mortar application. The cores shall be examined for evidence of poor workmanship by the Engineer-in-Charge, and if he is satisfied that either the bonding work or the subsequent layer of mortar are not of the required workmanship, the contractor at the instruction of Engineer-in-Charge shall

dismantle such areas of work as required by the Engineer-in-Charge and re-do the same after re-preparing the surface by chipping off mortar work and abrading the bonding slurry interface.

1.5.7.4 Measurements:

Pre-measurement of dimensions of plaster patches shall be measured correct to a centimeter and area worked out in square metres correct to second place of decimal. The pre-measurement of the average thickness shall be done by taking an average of five thickness readings recorded with one reading each at corner and at the point of intersection of wires stretched diagonally from corner points of the rectangular area chipped.

1.5.7.5 Rates

The rates shall cover cost of all materials, labour and T&P involved in all the operations described above. The payment shall be made on the actual consumption of cement on kilograms basis.

Note : In respect of materials supplies, two stage payment shall be made. In the first stage 75 % of the rates quoted be released after the materials are brought to site of work and tested satisfactorily. Balance 25 % of the rates quoted shall be released in the second stage, which will be after their consumption in the work.

1.5.8 EPOXY MORTAR :

PURPOSE: *To carry out structural repairs to prepared patches of spalled c oncrete with an epoxy repair mortar comprised of resin, hardener and specified silica sand.*

1.5.8.1 Materials and T&P:

Epoxy comprising of resin and hardener in proportions as specified by manufacturer and shall conform to ASTM C-882, Silica sand falling in Zone-II as per IS:383, mechanical mortar mixer, spatulas, trowels, etc.

1.5.8.2 Procedure:

Step-1 **Follow the guidelines** for Safety, Quality Assurance, Environmental Protection, Product delivery, Personnel, Supervision, Storage and Handling, etc given in Para 1.0.

Step-2 **Full quantity of specified resin, hardener and silica sand shall be received** at site in factory sealed containers with labels legible and intact provided that the shelf life so permits. Otherwise substantial quantity as could be consumed within the storage period shall be received as per quantity approved by Engineer-in-Charge. Full quantity shall be worked out as theoretically required for consumption in the whole work.

Step-3 **Testing of Material:** The requisite number of test specimens of mortar shall be cast from each batch of manufactured or supplied materials received (whichever is less) for these to be tested for conformance to the specified requirements contained in Table 5.8 before use on the work in general. Epoxy Mortar of Resin: Silica sand proportion as 1:7 shall have the following properties

Specific gravity	1.87+ 0.05
Minimum gel time	30 minutes
Bond strength after 7 days curing at 25^{0}C	75-100 Kg/sqcm
Compressive strength at 7 days curing at 25^{0}C	800-1200 kg/sqcm
Split Tensile strength after 7 days curing at 25^{0}C	100 -130 kg./sqcm
Flexural Strength after 7 days curing at 25^{0}C	295 Kg/sqcm

Step-4 **Identify and mark the area** for epoxy mortar repair.

Step-5 **Surface Preparation:** The appropriate propping/supporting, surface preparation and crack sealing as per site requirements shall be completed, which may sequentially cover one or more of the following items of work:

a) Prop & support the structural member to relieve it of stress and strains (Refer Para 1.1.1)

b) Removal of existing surface plaster/treatment shall be done according to Para 1.2.1 or 1.2.3 as the case may be.

c) Chipping unsound/weak concrete material shall be done according to Para 1.2.2.

d) Removing concrete all around embedded rusted reinforcement shall be done according to Para 1.2.6.

e) Removing and cleaning reinforcement of rust from its surface to give it a shining bright metal shall be done according to Para 1.2.7.

f) Sealing the cracked or honeycombed concrete with injection grouting shall be done according to Para 1.3.1 and 1.3.2

g) Providing and inserting mild steel shear key bars shall be done with minimum 3 nos per square meter of surface area of substrate according to Para 1.2.9, which may also be used as depth measuring gauge.

h) Additional reinforcement, if required, shall be tied with required overlaps or welded.

i) The rust, if any, persisting over the existing exposed reinforcement or the new reinforcement shall be removed mechanically or chemically, as per Para no 1.2.7.

j) Cleaning of lightly sticking materials and foreign matter from the exposed concrete surface and steel reinforcement by suitable means shall be done according to Para 1.2.10

Step-6 **Inspection of concrete surface** prior to adhesive application shall be thoroughly inspected and got approved by the Engineer-in-Charge. Surfaces shall be ensured to be free from any deleterious materials such as oil, dust, dirt etc. using oil free air blast.

Step-7 **Alignment & thickness Control**- Ground wires shall be fixed at reference points to measure and control the thickness of repair mortar. Shear keys fixed earlier could also function as depth gauges. Adequate ground wires shall be installed to establish thickness and surface planes before application of repair mortar. Ground wires shall be tight and true to line and placed in such a

manner that they may be further tightened.

Step-8 **Apply Passivating & bonding** coat over the cleaned existing and new reinforcement according to Para 1.4.2.

Step-9 **Apply epoxy bond coat** on the cleaned concrete substrate according to Para 1.4.2. Work of application of primer coat shall not be allowed to be performed beyond 40^0C atmospheric temperature and/or pot life of epoxy.

Step-10 **Mix and Prepare Epoxy Mortar** to have a uniform consistency and texture in a mechanical mixer by adding resin, hardener and silica sand as weigh batched ingredients of the mix.

Use of pre-packed ready to use components supplied by manufacturers in containers may be allowed subject to approval of Engineer-in-Charge. In case where pre-packed ready to use materials are to be used, the contractor shall submit the manufacturer's certificate verifying conformance to material specification as specified, manufacturer's mixing and application procedure for approval by Engineer-in-charge.

Plastering with epoxy mortar immediately after applying the epoxy bonding coat (Refer 1.4.2) to the prepared surfaces shall be done by trowel, roller or spray equipment, at a thickness not less than, nor more than that recommended by manufacturer,

The mortar shall be worked into place and consolidated so that all contact surfaces are wet by the mortar and the surfaces shall be finished by wooden floats or steel trowels.

All concrete surfaces shall be well protected beyond limits of surface receiving primer coat or mortar, against spillage.

. Step-11 **Air cure the epoxy mortar** surface for 24 hrs at ambient temperature or as per manufacturer's specification, if specified otherwise.

Step-12 **Test the Surface** after 24 hrs days cured epoxy mortar for soundness by tapping or sounding with hard blunt surface.

1.5.8.3 Inspection & Quality control:

The mortar application work shall be continuously inspected by a qualified supervisor who shall check materials, application of mortar, curing, stoppage of work during low temperatures and high winds etc. Each completed work of mortar shall be systematically sounded with a hammer to check for drummy areas after hardening.

In suspect areas or whenever directed by Engineer-in-Charge, the contractor shall drill the cores from the finished work and in to the host concrete after 24 hrs of mortar application. The cores shall be examined for evidence of poor workmanship by the Engineer-in-Charge, and if he is satisfied that either the bonding work or the subsequent layer of mortar are not of the required workmanship, the contractor at the instruction of Engineer-in-Charge shall dismantle such areas of work as required by the Engineer-in-

Charge and re-do the same after re-preparing the surface by chipping off mortar work and abrading the epoxy interface.

1.5.8.4 Measurements:

Pre-measurement of dimensions of plaster patches shall be measured correct to a centimeter and area worked out in square metres correct to second place of decimal. The pre-measurement of the average thickness shall be done by taking an average of five thickness readings recorded with one reading each at corner and at the point of intersection of wires stretched diagonally from corner points of the rectangular area chipped.

10.5.8.5 Rates

The rates shall cover cost of all materials, labour and T&P involved in all the operations described above. The payment shall be made on the actual consumption of resin plus hardener on kilograms basis.

1.5.9 DRY PACK AND EPOXY BONDED DRY PACK:

PURPOSE: *To carry out structural repairs to prepared patches of spalled concrete with an epoxy repair mortar comprised of resin, hardener and specified silica sand.*

1.5.9.1 General: The work shall be carried out as per description of the item of work given in Para 8.5.9, general guidelines & description given Para 6.5.2 and directions of the Engineer-in-Charge

1.5.9.2 Measurements:

Pre-measurement of dimensions of patches shall be measured correct to a centimetre and volume worked out in Cubic metres correct to second place of decimal. The pre-measurement of the average thickness shall be done by taking an average of fibre thickness readings recorded with one reading each at corner and at the point of intersection of wires stretched diagonally from corner points of the rectangular area clipped.

1.5.9.3 Rates

The rates shall cover cost of all materials, labour and T&P involved in all the operations described above.

1.5.10 PREPLACED AGGREGATE CONCRETE:

PURPOSE: *To carry out structural strengthening of concrete.*

1.5.10.1 General: The work shall be carried out as per Para 6.5.3 in general and as per specification and directions of the Engineer-in-Charge

1.5.10.2 Measurements:

Pre-measurement of dimensions of surface shall be measured correct to a cm. and volume worked out in square metres per layer correct to second place of decimal.

1.5.10.3 Rates

The rates shall be cover cost of all materials, labour and T&P including grout pump etc. involved in all the operations describd above. Shuttering and priming/bonding coat, if applied, shall be paid separately as per the relevent item.

1.5.11 STRENGTHENING WITH HYBRID ORTHOGONAL WOVEN FABRIC SYSTEM SOAKED IN EPOXY:

PURPOSE: *To increase the load carrying capacity (shear, flexural, compressive) and ductility of reinforced concrete members through a non-intrusive structural strengthening technique comprised of the Composite Fiber System, without causing* any destruction or distress to the existing concrete.

1.5.11.1 General: The work shall be carried out as per Para 6.5.18 in general and as per specification and directions of the Engineer-in-Charge

1.5.12 STRENGTHENING WITH UNIDIRECTIONAL HIGH STRENGTH FIBRES OVER EPOXY COATED SURFACE

PURPOSE: *To increase the load carrying capacity (shear, flexural, compressive) and ductility of reinforced concrete members through a non-intrusive structural strengthening technique comprising of unidirectional E-glass fiber and 0.4 mm effective thickness, complete*

1.5.12.1 General: The work shall be carried out as per Para 6.5.18 in general and as per specification and directions of the Engineer-in-Charge.

1.6 CURING

1.6.1 CURING OF SHOTCRETED, PLASTERED AND/OR RCC SURFACES ETC.:

PURPOSE: *To ensure satisfactory hydration of cement by retaining or replenishing the mixing water lost due to natural drying and evaporation process for a specified period through exposed cementitious surfaces of the freshly placed cement mortar/ concrete.*

1.6.1.0 General:

Importance of wet curing to all items of work involving use of cement need not be over emphasised. It is important to note that the measurement and payment of all relevant items involving use of cement such as shotcrete, plaster, RCC etc. is subject to the precondition of successful execution of the item of curing.

Any surface experiencing discontinuity of dampness of surface with any patch having dried out during the specified period of curing, it shall be prominently marked with lime or other suitable prominent colour. Measurement and payment of such portion shall neither be made under the item of curing nor under the relevant items of shotcrete, plaster or RCC etc but rejected & redone.

1.6.1.1 Materials and T&P

Curing compound, brush or hand operated spraying gun and all other related accessories for application on Concrete/Plastered Surface.

1.6.1.2 Procedure:

Step-1 **Follow the guidelines** for Safety, Quality Assurance, Environmental Protection, Product delivery, Personnel, Supervision, Storage and Handling, etc given in Para 1.0.

Step-2 **Full quantity of specified manufactured material shall be received** at site in factory sealed containers with labels legible and intact provided that the shelf life so permits. Otherwise substantial quantity as could be consumed within the shelf life shall be received as per quantity approved by Engineer-in-Charge. Full quantity shall be worked out theoretically for consumption in the whole work.

Step-3 **(A) Moist Curing:**

Cover all exposed surface of concrete, when the concrete begins to harden i.e. two to three hours after compaction with moist gunny bags or any other material approved by the Engineer-in-Charge.

Keep the exposed surfaces continuously damp after its final setting (i.e. after a maximum of 8 hours of concreting) by ponding with a sheet of water or by covering with a layer of sacks, canvass, hessian or similar water absorbent materials constantly kept wet by water sprinkling for at least 7 days, where ordinary portland cement is used and 10 days, where portland pozzolana cement is used from the date of placing of concrete. For concrete work with other types of cement, curing period shall be as per manufacturer's recommendations or as directed by the Engineer-in-Charge.

(B) Using Curing compound:

Testing of Materials: It must be ensured that curing compound should neither affect the strength nor the surface of concrete. It shall not leave any undesirable stains on surface to affect the bond of plaster or other finishes to be applied later. It should be soluble in water, so that it can be removed by splashing or washing with water without scrubbing the surface.

Test for Efficacy: The testing of curing compounds shall be done from each lot of curing compound received at site by casting two sets of 15 cm cubes with each set having 6 cubes. One set shall be moist cured by covering with damp gunny bags and subsequently by immersing under water and the other set by applying curing compound on top after 2 to 3 hours of casting and subsequently on de-moulding apply on the remaining faces all around. The cubes shall be kept in an environment similar to which the actual structure is exposed for a period of 7 days after its casting. Three concrete cubes each from both sets shall be tested after 7 days for their crushing strength as per test procedure specified in clause 5.4.9.1 of CPWD specification 1996 Vol-II under identical condition. The average crushing strength of cubes cured with curing compound shall be not less than 95% of the crushing strength of cubes cured under damp or immersion curing.

Test for Staining: The set of three sample cubes applied with curing compound, remaining after 7-day cube crushing strength test, shall be washed with water with soft brush scrubbing with nylon bristles and allowed to dry for a period of seven days in an atmosphere with relative humidity not exceeding 40% at ambient temperature. The other set of three cubes cured for seven days under damp or immersion conditions shall also be kept for another seven days under identical humidity and temperature conditions. The surface of the two

sets of such cubes shall be compared by closely observing for any visible stain and texture that may detrimentally affect its bond with subsequently applied plain plaster or aesthetic appearance. Such observations shall be recorded in three categories as no effect, slight effect and moderate effect. The curing compound shall be considered as acceptable in the 'no effect' category and unacceptable in the 'moderate' category. The decision of Engineer-in-Charge, which shall be final and binding, based on the likely use of finished surface of concrete/plaster shall determine the acceptability of the 'slight effect' category.

Concrete curing compounds, after testing satisfactorily for efficacy, may be used in lieu of moist curing with the permission of the Engineer-in-Charge. Such compounds shall be applied to all exposed surfaces of the concrete by spraying or brushing within two to three hours of casting and well within an hour of removal of formwork.

1.6.1.3 Measurements:

Dimensions of exposed surface of concrete wet cured shall be measured correct to a centimeter and areas worked out in square metres correct to second place of decimal.

1.6.1.4 Rate:

The rates shall cover cost of all materials, labour and T&P involved in all the operations described above**.**

Note : In respect of materials supplies, two stage payment shall be made. In the first stage 75 % of the rates quoted be released after the materials are brought to site of work and tested satisfactorily. Balance 25 % of the rates quoted shall be released in the second stage, which will be after their consumption in the work.

1.7 CHHAJJA/SUN SHADES

1.7.1. SPECIFIED SAND STONE CHHAJJA:

PURPOSE: *To protect the windows/ doors, etc located on the exterior of the building from heat and water due to sun or rain etc.*

1.7.1.1 Materials and T&P

Specified angle iron, sand stone, zinc rich and tar-epoxy resins and hardeners, cement concrete, all applicable T & P complete with necessary accessories.

1.7.1.1 Procedure:

Angle iron frame for chhajja shall be fabricated correct to required size at ground & fixed in position in the wall as per the standard drawing.

Steel work in frame shall conform to the provisions of Para 10.4 of CPWD specifications 1996 Vol.-III. However, steel frame work shall be given priming coat Zinc rich epoxy coating followed with two coats of tar-epoxy paint.

The specified sand stone shall conform in general to the provisions of Para 7.8 of CPWD specifications 1996 Vol-II. Size of stone shall, however, be as specified.

Frame shall be tightly embedded into the masonry with cement concrete 1:3:6

(1 cement: 3 coarse sand : 6 graded stone aggregate 20 mm) blocks 150 mm x 115mm x 230 mm.

Junction of wall & the chajja shall be finished with cement concrete gola for proper drainage of rain water. Gola shall conform to the provisions in Para 12.15 of CPWD specification 1996-Vol-IV.

The exposed surfaces of the angle iron frame and chajja shall be finished with two or more coats of tar epoxy paint.

1.7.1.3 Measurements:

The projected length & breadth of the chajja shall be measured correct to a centimeter & area shall be worked out in square metres correct to second place of decimal.

1.7.1.4 Rates:

Rate for the item includes the cost of all labour, materials & T&P involved in operations stated above except for the scaffolding, which shall be payable separately.

1.7.2 AVERAGE 25 MM THICK FERRO-CEMENT CHAJJA/WEATHER SHADE ETC.:

PURPOSE: *To protect the windows/ doors, etc located on the exterior of the building from heat and water due to Sun or rain etc with a suitably formed chhajja projection.*

1.7.2.1 General: In most of the cases the ferrocement chhajjas are factory made and they are fixed at site using partially cast in situ ferrocement components using existing embedded steel reinforcement or with suitable structural steel framework. However precautions are to be taken against seepage of water by providing Gola above the Chhajja at junction with wall as per CPWD specifications. Work shall be carried as per the specifications and directions of Engineer-in-Charge.

1.8 WATER PROOFING & PROTECTIVE COATINGS

1.8.1 POLYMER MODIFIED CEMENT SLURRY WATERPROOFING AND ANTICARBONATION COATING:

PURPOSE: *To protect the RCC surface against ingress of aggressive environmental deteriorating agents like carbon dioxide, water vapours, etc to substantially reduce the rate of carbonation of concrete and ingress of water.*

1.8.1.1 General: The Para 1.4.1 generally applies for this item. The work shall accordingly be carried out as per nomenclature of Item and directions of Engineer-in-Charge.

1.8.2 UV RESISTANT ACRYLIC POLYMER BASED WATER PROOF COATINGS:

PURPOSE: *To protect the exposed surface of RCC roof against ingress of, water vapours, etc to provide a UV resistant, flexible, elastic, water proofing membrane.*

1.8.2.1 General: It is a thin water proofing membrane applied with brush comprised of UV resistant Acrylic Emulsion to be applied over a primer coat. The work shall be carried out as per manufacturer's specifications and as per directions of Engineer-in-Charge.

1.8.3 FERRO-CEMENT WATER PROOFING TREATMENT:

PURPOSE: *To provide protection against ingress of water, etc through RCC surface with a structural membrane of cement matrix reinforced with layers of small diameter steel wire mesh and structurally connected to the exposed surface of RCC.*

1.8.3.1 General

The ferrocement being a structural membrane is gainfully utilised as a stiff membrane to resist ingress of water from exposed RCC terraces. It is also used as inside tanking membrane for RCC raft and walls to arrest leakage of water in existing basements.

Materials used for the work shall be strictly according to specification. Utmost care shall be taken to ensure good workmanship. On extremely hot days, the work shall be carried out only in the late afternoon or early morning.

1.8.3.2 Materials and T&P:

Cement shall be Ordinary Portland Cement of 33 grade conforming to IS:269 or 43 grade conforming to IS:1489 as may be specified.

Sand shall conform to grading Zone-II as per IS:383

Admixtures shall be used to improve workability, reduce water demand and to retard the mortar setting time.

Reinforcement: 22 gauge orthogonal woven G.I. wire mesh, 4mm dia G I wires

In most cases, hand mixing is satisfactory. If mixing is to be done for large structures or factory made components, horizontal paddle bladed mixer shall be required.

1.8.3.3 Procedure:

Step-1 **Remove & scrap** all treatment including non-cementitious tarfelt, bitumen, etc from the surface to be treated (Refer Para 1.2.3 payable separately).

Step-2 **Repair the exposed roofing and its junctions with parapets**, including sealing of cracks & honey combed area (Refer Para 1.3.2 payable separately).

Step-3 **Regrade the roofing, if required and re-lay the Khurrahs**. Provide adequate slope towards the rainwater spouts.

Step-4 **Cut a chase of 75 mm X 75 mm** in parapet at the junction with roofing for taking the Ferrocement water proofing treatment inside the chase.

Step-5 **Fix hot dip galvanised wire nails** 50 mm to 60 mm long & 4 mm dia to roofing along marked grid points at a spacing of 450 mm as shown in the Fig 1.8.3.1. The fixing shall be done by drilling 25 mm deep holes of appropriate diameter with high speed drill, blowing away the dust from drilled holes with a hand operated blow out pump or air compressor, injecting epoxy from the cartridges with epoxy dispenser/cartridge holder through PVC mixing nozzle and inserting the nails in vertical position with remaining length as projecting above the roof surface. The epoxy shall be allowed to air cure for 24 hours.

Step-6 **Lay over the roofing, 4 mm dia galvanised steel wires** laid parallel to each other spaced at 450mm c/c along the layout of GI wire nails. Wires shall be taken alternately along the either side of GI nails in order to fix their position.

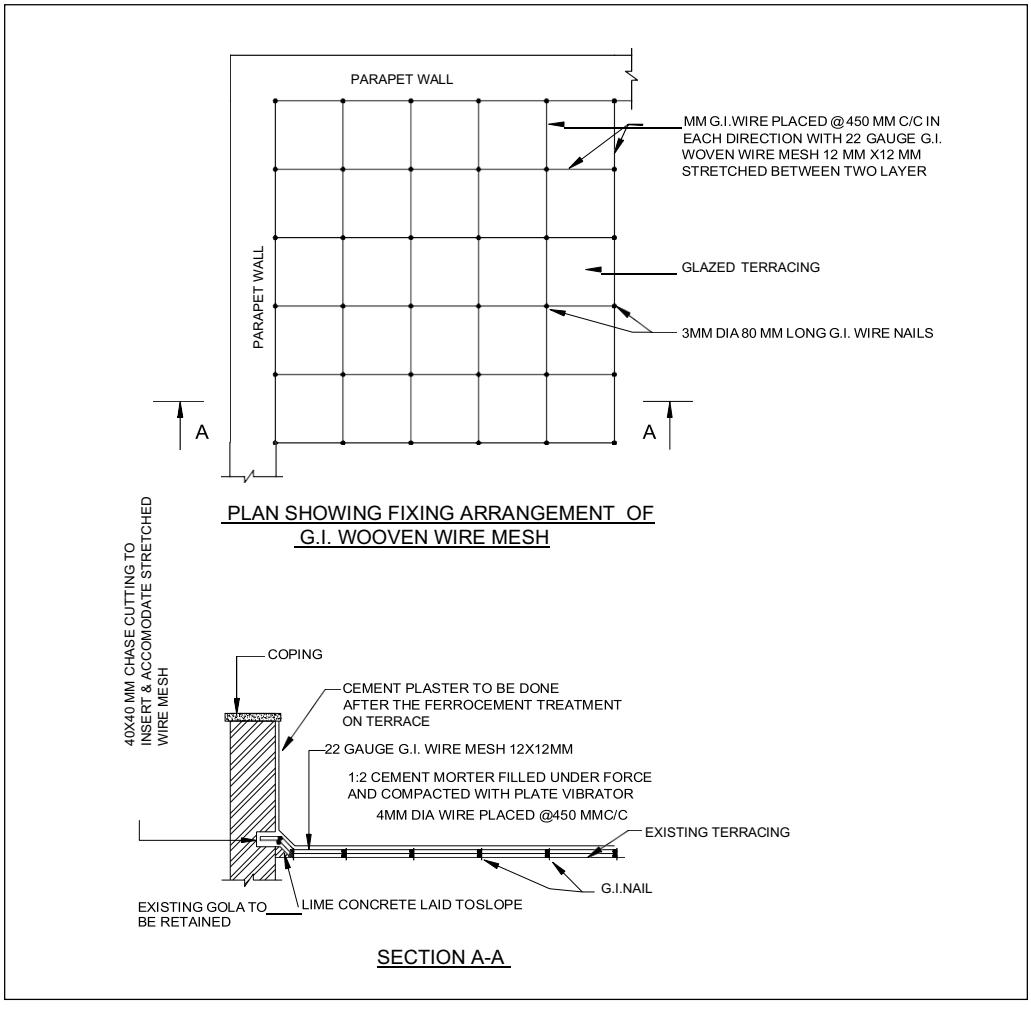
Step-7 **Apply a coat of bonding slurry** (Refer Para 1.4.1 and payable separately)

after saturating the surface with water but without excess water. The area to be covered with bond coat shall be in parts and just enough for all the operations of ferrocement to be finished by close of the day.

Step-8 **Lay the first layer of specified woven wire mesh and tightly stretch** over roof surface from one end so that the nails are inserted in the meshes to keep it in tightly stretched condition. The woven mesh shall be orthogonally woven with 22 gauge hot dip galvanised wires spaced at 12 mm c/c. The mesh shall be seated over 4 mm dia GI wires laid in step-6. In the laid woven wire mesh, the over laps of 100 mm shall be given along the sides and ends.

Step-9 **Weigh batch Cement and specified sand** (while operations of Steps-6,7, 8 & 9 are in progress), in proportion 1: 2 (1-cement: 2-sand) and dry mixed before adding a measured quantity of admixture and water. The water to cement ratio shall be maintained not more than 0.4. Mixing, if done in a mechanical mixer, shall be done for about three minutes to form a plastic mortar of uniform colour and texture.

Step-10 **Lay another set of 4 mm dia wires** at right angle to lower layer of GI wires at 450 mm c/c in same manner as at Step 4. This shall be done to provide a 4 mm clear gap between the first woven wire mesh & the next one yet to be laid. For 25 mm thickness of ferrocement the top 5 mm thickness shall only be made up by



increasing the cover thickness in only mortar.

Step-11 **Spread second layer of woven square mesh** of 22 gauge hot dipped galvanised wire with wires spaced at 12 mm c/c as per procedure explained in Step-8.

Step-12 **Provide Levelling/Thickness gauges** by bending the projected nails to U shape, which will also ensure that the mesh is fixed in position. Mortar gauges of specified thickness shall also be provided in a square grid at an interval of about one metre c/c.

Step-13 **Apply the mortar** using trowels by force, rubbing and pressing down with trowels so as to ensure penetration in the wire meshes. There shall be a minimum mortar cover of 4 mm below the mesh, between the meshes and over it. The mortar shall be compacted thoroughly using a vibrating trowel or an orbital vibrator and finished smooth to specified thickness. The surface shall be finished semi smooth and to the required slope.

Step-14 **Provide Cement Concrete Gola** in the Chase provided earlier at Step-4 as per CPWD Specifications 1996.

Step-15 **Curing:** Refer Para 1.6.1 But the period of wet curing shall be 14 days. For the next two weeks, it shall be gradually allowed to dry. Care shall be taken to ensure that ferrocement does not dry up in the first two weeks.

1.8.3.4 Measurement:

Dimensions of the area covered with ferrocement treatment shall be measured correct to a centimeter and area worked out in square metres correct to second place of decimal.

1.8.3.5 Rates:

The rates shall cover cost of all materials, labour and T&P involved in all the operations described above except step 15.

1.8.4 CEMENT PLASTER WITH POLYMERIC WATER PROOFING COMPOUND:

1.8.5 ***PURPOSE: To provide a barrier against ingress of water/dampness through RCC/ Brickwork etc with plaster in cement matrix made impervious or hydrophobic by addition of polymeric pore sealants.***

1.8.5.1 Materials, Procedure, Measurements and Rates

The polymeric water proofing compound shall conform to the requirements given in Chapter-5. Others shall generally conform to the description of the item given in Para of Chapter-8 and CPWD Specifications 96 Vol-IV.

1.8.6 INJECTION TYPE POST CONSTRUCTION WATER PROOFING TO CONCRETE STRUCTURES:

PURPOSE: *To seal pores of existing concrete structures against ingress of water and moisture by pressure injection of pore sealing compounds through nipples fixed for the purpose.*

1.8.6.1 Materials, Procedure, Measurements and Rates

These shall generally conform to the description of the item given in Para 8.8.6 of Chapter-8 and Para 1.3.2.

1.9 MASONRY REPAIR

1.9.1 General:

Masonry repair is done by various types of repair material. Of those covered in sub paras of para 8.9, cement mortar and cement concrete the relevant sections of CPWD Specifications 1996 Vol-I & II may be referred. Whereas for gunite/ shotcrete, polymer modified cement mortar, bond coat relevant respective Paras at 1.5.2, 1.5.4, 1.4.1 are required to be referred. The work is required to be executed, measured and paid as per nomenclature of items of work. The individual specifications are not being given for the sake of brevity. The item of curing covered in Para 9.6.1 is required to be executed, measured before measuring and making payment of any of the items of masonry repair.

2.0 TESTING OF MATERIALS AND PRE / POST REPAIR STRUCTURE

The pre and post repair testing of a structure for evaluation purposes shall generally be carried out in accordance with sub paras of Para 8.10 and relevant standards mentioned therein and relevant tests indicated in Chapter-3 of this Handbook.

Appendix 1.1

TEST METHODS FOR EXECUTION OF THE WORKS

A1.1.1 General

(1) Table A1.1-1 given hereinafter reviews the test methods to be used during execution of the works in accordance with these specifications.

(2) Column 1 shows the property to be tested for which requirements are specified Tables 1.1 to 1.7.

(3) Column 2 indicates whether the test can be performed using resources available on the construction site or whether a testing agency must be called in. The construction site and the testing agency cooperate in cases where specimens are taken on the site and tested at the testing agency. A specialist laboratory must be employed in cases where neither the construction site nor the testing agency possesses adequate facilities.

(4) Column 3 indicates the section of this Handbook or BIS code of practices in which the description of the method is given.

Table A1.1-1: Test methods for execution of the works

	Property	To be tested by	Description of test method, see section/BIS Code of Practice.
	Concrete substrate		
1.	Apparent nature	Construction site	A1.2.1.
2.	Concrete compressive strength	Construction site and testing agency	3.2.1
3.	Surface tensile strength	Construction site and testing agency	3.2.1.4
4.	Carbonation depth	Construction site	3.2.2.1
5.	Concrete cover, position and diameter of reinforcement	Construction site	A1.2.2
6.	Chloride content	Construction site and testing agency	3.2.2.2
	Moisture content of the concrete		
7.	- by heating surface	Construction site	A1.2.3
8.	- with CM apparatus	Construction site	A1.2.4
9.	- Gravimetrically	Specialist Laboratory	–
10.	Water penetration	Testing agency	A1.2.5
11.	Wettability	Construction site	A1.2.6.
	Roughness		
12.	- sand area method	Construction site	A1.2.7
13.	-With inductivement -displacement sensor	Specialist Laboratory	–
	Crack State		
14.	- Crack-width rule, crack magnifier, plaster mark	Construction site	A1.2.8
15.	Crack propagation- Glass Strip marker	Construction site	–

	Property	To be tested by	Description of test method, see section/BIS Code of Practice.
16	Crack- indicating caliper and inductive displacement sensor	Specialist laboratory	–
	Processing Conditions		
17.	Air temperature and atmospheric humidity, component temperature, dew-point temperature	Construction site	A1.2.9
	2. Repair concretes or mortars		
	2.1 Aggregate		
18.	Granulometric composition	Construction site	IS:383
19.	Inherent moisture, surface moisture, core moisture	Construction site	IS:383
	2.2 Mortar		
19.	Consistency, apparent specific density, air content	Construction site	–
20.	Flexural tensile and compressive strength and apparent specific density	Construction site and testing agency.	IS:516
	2.3 Concrete (IS:456)		
21.	Consistency, apparent specific density, air content	Construction site	–
22.	Concrete composition	Testing agency	–
23.	Water content (dehydration test)	Testing agency	–
24.	Compressive strength	Construction site Testing agency	IS:516
25.	Impermeability to water	Construction site and testing agency	–
	2.4 Shotcrete		
26	Consistency	Construction site	1.5.3
27	Apparent specific density	Construction site	–
28	Water/cement ratio	Testing agency	–
29	Concrete composition	Testing agency	–
30	Compressive strength	Construction site and testing agency	1.5.3
	3. Surface protection systems		
	Coating thickness		
31	- Wedge-cut method	Testing agency	–
32.	- Drilled core	Testing agency	A1.4.1
33.	Adhesive strength	Construction site and testing agency	A1.4.2
34.	Voids content (SP 9 and 10)	Testing agency	A1.4.3
35.	Leakage resistance	Testing agency	–
36.	Grid test with tape test	Specialist laboratory	A1.4.4
	4. Treatment of cracks		
37.	Degree of filling	Testing agency	A1.5.1.
38.	Cement paste	Testing agency	A1.5.2

A1.2 Concrete Substrate

A1.2.1 Visual Checks

(1) **Visual checking** of the surface is done for the presence of:

- Hardened cement slurry, loose particles such as dust, etc
- Original Construction Defects e.g. gravel pockets, ridges, honey-comb, segregated concrete surface, powdering & sanding, etc
- Efflorescence, leaching and weathering of the fine mortar layer
- Concrete spalling (e.g. above reinforcement),
- Moisture penetration and its entry points,
- Growths (e.g. mosses, higher plant organisms).
- Contamination by foreign matter, e.g. oil, grease, paraffin, rubber particles, parting agents, after-treatment agents and residues of old coatings.
- Cracks (crack width, crack type and appearance).

(2) **Near surface cavities** can be detected by hollow sounds on percussion. Powdering, sanding and dust coatings can be quantified by applying an adhesive strip of defined size to the surface and pulling it off.

A1.2.2. Determination of Concrete Cover, Position and Diameter of the Reinforcement

(0) The concrete cover, position and diameter of the reinforcement are to be measured and recorded non – destructively using an electronic tester called rebar locator or profometer. The directions for use, as per manufacturer's instruction manual, govern the way in which the test instruments are used. The accuracy of the instruments is to be checked periodically for example on already exposed reinforcement or by exposing a localized area of the reinforcement.

(1) Destructive measurement of the concrete cover should be used only in exceptional cases.

A1.2.3 Testing the Moisture Content of the Concrete Surface Zone by Heating the Surface.

Concrete surface is termed as "dry", "moist" and "wet" as follows:

- "Dry" – A freshly created fracture of concrete surface with depth of about 20 mm must not become visibly lighter in colour as a result of drying out than before. In case concrete contains equilibrium moisture for the environment, it is deemed to be dry.
- "Moist"- When the surface of concrete has a matt appearance without any shiny water film and the concrete surface absorbs fresh drops of water applied to its surface, leaving the surface matt again in a short time (i.e. the surface pore structure is not saturated), the surface is termed as moist.
- "Wet"- When the pore structure of concrete surface is water saturated, there may be a surface shine on the concrete but no excess surface water film

The surface of the concrete or of a roughly 2 cm deep freshly reptured surface may be heated, for example with a hot air dryer (i.e. hair dryer), to indicate the presence of concrete moisture exceeding the definition "dry". The moist concretes appear significantly lighter after heating.

A1.2.4 Testing the Moisture Content of the Concrete Surface Zone with a CM Device.

a) Purpose and Use:
The method may be used to determine the moisture content of the concrete substrate.

b) Brief Description:

(1) Pieces of concrete removed from the concrete surface zone are crushed rapidly with a pestle in a porcelain bowl and weighed. The sample (Table A1.2) is placed in a pressure bottle together with a quantity of calcium carbide (5 g glass ampoule). The bottle is shaken vigorously several times, so that previously added steel shot breaks the glass ampoule. The mixing of the sample and the calcium carbide allows a chemical reaction between the water in the sample and the calcium carbide, releasing acetylene gas. The resulting gas pressure is proportional to the moisture content of the sample, and is read off via a pressure gauge.

(2) The moisture content associated with a particular pressure reading is given in Tables A9.3. to A9.5

Table A1.2: Required weight

	Estimated moisture content 1	Required weight 2	
		Mortar	Concrete
1.	1.05% to 2.5 %	50 g	50 g
2.	3.0 % to 5.0 %	20 g	20 g
3.	5.5% to 7.0 %	20 g	10 g
4.	More than 7 %	10 g	10 g

Table A1.3: Pressure in bar for maximum grain size up to 4 mm

Pressure for 50 g weight			Moisture content [%]	
	1	2	3	4
	after 15 min	**after 20 min**	**after 25 min**	
1.	—	—	0.330	1.0
2.	—	—	0.495	1.5
3.	—	—	0.655	2.0
4.	—	—	0.820	2.5
	Pressure for 20 g weight			
	ater 15 min	**after 20 min**	**after 25 min**	
5	—	0.380	0.390	3.0
6	—	0.500	0.510	3.5
7	—	0.615	0.625	4.0
8	—	0.735	0.745	4.5
9	—	0.855	0.865	5.0
10	—	0.970	0.980	5.5
11	—	1.090	1.100	6.0
12	—	1.325	1.335	7.0

Table A1.4: Pressure in bar for maximum grain size up to 8 mm

	Pressure for 50 g weight			Moisture content [%]
	1	2	3	4
	after 15 min	**after 20 min**	**after 25 min**	
1	—	—	0.335	1.0
2	—	—	0.510	1.5
3	—	—	0.685	2.0
4	—	—	0.860	2.5
	Pressure for 20 g weight			
	after 15 min	**after 20 min**	**after 25 min**	
5	—	0.405	0.415	3.0
6	—	0.550	0.560	3.5
7	—	0.690	0.700	4.0
8	—	0.835	0.845	4.5
9	—	0.975	0.985	5.0
10	—	1.120	1.130	5.5
	Pressure for 20 g weight			
	after 15 min	**after 20 min**	**after 25 min**	
11	0.475	0.480	0.485	5.5
12	0.530	0.535	6.0	

	Pressure for 50 g weight			Moisture content [%]
	1	2	3	4
	after 15 min	**after 20 min**	**after 25 min**	
1	—	—	0.340	1.0
2	—	—	0.605	1.5
3	—	—	0.870	2.0
4	—	—	1.130	2.5
	Pressure for 20 g weight			
	after 15 min	**after 20 min**	**after 25 min**	
5	—	0.580	0.585	3.0
6	—	0.750	0.755	3.5
7	—	0.915	0.925	4.0
8	—	0.085	1.095	4.5
9	—	1.255	1.270	5.0
	Pressure for 10 g weight			
	after 15 min	**after 20 min**	**after 25 min**	
10	0.715	0.725	0.730	5.5
11	0.845	0.850	0.855	6.0

c) Test apparatus and other materials required

- CM pressure bottle with pressure gauge.
- Electronic scales (accuracy 0.1 g)
- Analytical sieve with 2 mm mesh size
- Porcelain Bowl (with collar ring to prevent portions of the sample escaping) with a pestle
- Steel shot, calcium carbide ampoules, stopwatch
- Hammer and chisel
- Other accessories.

d) Procedure

Step-1 Use the hammer and chisel to remove fragments of the concrete under test to a depth of 2 cm (10 to 50 g).

Step-2 Use the hammer to crush the fragments in the porcelain mortar (do not crush individual aggregategrains)

Step-3 Pass the sample through an analytical sieve (mesh size 2 mm).

Step-4 Weigh out the required sample (see Table A1.2) on the electronic scales.

Step-5 Place first the steel shot and then the weighed sample in the bottle, without losing any of the sample.

Step-6 Tilt the bottle slightly and carefully slide in an ampoule of calcium carbide.

Step-7 Place the cap with pressure gauge on the bottle and secure it with the tightening levers.

The above operations must be carried out quickly, to avoid loss of moisture.

Step-8 Break the glass ampoule by shaking the bottle with a vigorous rotary motion.

Step-9 Repeat the shaking operation once every 5 minutes up to the final reading.

Step-10 Determine the moisture content (in W.%) as a function of sample weight and maximum grain size associated with the final pressure reading from Tables A1.3. to A1.5

Step-11 On completion of the test, open the bottle carefully (Caution : the bottle is under pressure) and allow the acetylene gas to escape (Caution : no naked flames).

Step-12 Carefully pour away the contents (Caution : un-hydrated lime and glass fragments) and clean the bottle with a clean bottle brush.

Step-13 Clean the steel shot with a dry cloth. Clean the bottom of the pressure gauge (rubber washer).

e) Likely sources of error

1) A substantial difference in temperature between the pressure bottle and the surroundings.

2) Bottle not gas-tight sealed (e.g. damaged washer, material residues under the rubber washer).

3) Calcium carbide ampoule leaking before insertion (light brown stain).

A1.2.5 Testing Construction Materials or Components for Water Penetration Using a Water Penetration Gauge

a) Purpose and Use

The water penetration test with a water penetration gauge indicates the behavior of a construction material or component in response to the effects of water, it measures the volume of water penetrating per unit time in a construction material which is air-dry at the beginning of the test.

b) Test Apparatus and other materials required

(1) The penetration gauge is supplied in two versions, for vertical and horizontal test surfaces. It consists of a glass measuring tube with a calibrated ml scale, opening at the bottom into a bell with a diameter of 30 mm.

(2) The water penetration gauge is sealed water tight to the test surface, using a plastic sealant (e.g. Plastellin, butyl rubber). For tests over a lengthy period, it is advisable to use an elastic curing sealant (e.g. silicon rubber).

c) Measuring Points

- The measuring points must be positioned in such a way that the test results are representative for the concrete under test. The measuring points must therefore be distributed throughout the test area or must be determined on statistical principles. The measuring points must be marked and the markings recorded in the test report.
- At least 6 measuring points must be used for each test area.

d) Procedure

Step-1: The sealant is placed in a collar round the edge of the bell. The bell is pressed on to the measuring point to form a watertight seal with the component surface. The sealant inside the bell should leave a circular area of the component with a diameter of roughly 20 mm exposed.

Step-2: To carry out the test, tap water is poured into the tube up to the zero mark, so that water in contact with concrete surface remains under a pressure of approximately 100 mm water column.

Step-3: The fall in the water level is measured at appropriate intervals. As soon as 1 ml to 2 ml of water have penetrated the concrete, the tube is refilled with water to the zero mark, to maintain approximately constant water pressure. The times of measurement, fall in the water level, temperature conditions and moisture state of the concrete surface are to be recorded in the report.

e) Test Report

The following items are to be recorded in the test report:
Quantity of penetrating water per unit time

Temperature conditions
Moisture state of the test area.

A1.2.6 Testing the Wet-ability of Concrete Surfaces

a) Purpose and Use:

The method supplies indicative values for assessing the absorptive capacity of concrete surfaces.

b) Brief Description:

The wettability of a concrete surface is tested by spraying it with water and assessing the pearling effect (no pearling, slight pearling or strong pearling).

c) Procedure:

- A spray bottle is used to place a few drops of water on the test surface. The result may be penetration of the surface zone, recognizable through the formation of dark stains, or more or less pronounced droplet formation (pearling).
- The pearling effect is influenced by the nature of the surface – chiefly its porosity and the degree of contamination – and, where relevant, by the type of surface treatment and the materials employed. It does not usually constitute a sufficiently reliable means of assessing the efficacy of impregnation measures.

A1.2.7 Determination of Surface Roughness Using the Sand Area Method.

a) Purpose and Use:

The method is used to determine the mean peak to valley height of a horizontal substrate surface. The test is carried out after pretreatment of the substrate.

b) Brief Description

(1) A defined volume of sand (Volume V) is distributed in a circular configuration on the test surface, in such a way that the dips are just filled.

(2) The mean peak to valley height Rt is defined as the height of an imaginary cylinder with a diameter d and a sand volume V.

c) Equipment and ancillary materials

- Vessel with a known internal volume V, e.g. 50 cm^3.
- Dry quartz sand, grain size 0.2 – 0.5 mm
- Hardwood disc (diameter 5 cm, thickness 1 cm) with a handle in the top center.
- Rule.

d) Measuring points

The measuring points must be positioned in such a way that the test results are representative for the test concrete. The measuring points must therefore be distributed over the test area or selected according to statistical principles. The measuring points must be marked and the markings recorded in the report. At least 3 measuring points must be used for each test area.

e) Execution of the test

- Fill the vessel with quartz sand and pour the contents on to the dry, clean surface.
- Rub the sand into the dips in the surface without applying pressure and using a spiral rotary motion until the dips are just filled.
- Measure the diameter of the circle.

The mean peak to valley height is obtained from the sand volume V (cm3) and the diameter d (cm) of the roughly circular sand distribution using the formula:

$$Rt = \frac{40\ V}{pd^2}\ (mm)$$

f) Test report
The mean peak-to-valley height in mm must be given in the report.

A1.2.8 Establishing crack characteristics:

a) General

(1) Special care must be taken when establishing the characteristics of cracks, in order to allow qualified assessment of the need for and type of crack – filling.

(2) On exposed structures, the most important crack characteristics (crack width and changes in crack width) are subject to weather – related changes. When these characteristics are established, at least the following additional data must therefore be recorded:

- date, time
- whether conditions, i.e. air temperature, cloud cover / rain (including values on preceding days)
- component temperature in the crack-influencing zone, both in the interior and on the surface of the component.

(3) Whether the change in crack width during the course of the day is observed, the relevant data must be recorded several times each day. Where changes in crack-width are traffic related, characterization of the traffic may be necessary in order to allow more effective analysis of the results. The selected measuring periods should be such that adequate conclusions on short term and daily changes in crack width at the planned filling time can be inferred from the results.

b) Measurement of crack width and changes in crack width

(1) Crack widths should be given to an accuracy of 0.1 mm. It will usually be sufficient to compare the crack width visually with a calibrated line on a line-width rule (draughtsman's rule). Experience is needed to use a crack magnifier; it does not invariably ensure greater accuracy and is not usually essential.

(2) Methods with differing sensitivity can be used to measure the changes in distance associated with changes in crack width:
Crack magnifier.
Thin plaster markers are applied by brush to the concrete surface. When the cracks in the concrete widen, cracks also appear in the plaster. Their width can readily be determined with the crack magnifier. Repeated readings to an accuracy of 0.01 mm can be used to follow slow changes in crack width, including long – term alterations. If necessary, a number of plaster markers may be applied at intervals to the same crack.
Laboratory methods:
These mechanically or electrically based methods can be used only by properly trained and experienced personnel. They register even extremely short-term changes to an accuracy of 0.001 mm.

(3) On superstructures of monolithic bridges and similar structures exposed to direct weathering, there are daily changes in crack width, in some cases dependent on insulation. The maximum changes are to be expected on cloudless days in the summer months, but not on days with high cloud cover and high air temperatures. At the maximum crack width, influences of traffic also usually lead to the extreme values of short-term changes in crack width.

c) Drilled cores

Drilled cores can be used to determine type of crack, the state of the crack and crack edges and any previous measures. Drilling cores invariably represents a disturbance, and should therefore be restricted to exceptional cases. Appropriately experienced personnel can often avoid the removal of drilled cores.

1.2.9. Testing the Processing Conditions

A1.2.9.1. Air Temperature

a) Apparatus and Instruments

(1) The following instruments may be used to measure the temperature of the air.:

- mercury thermometers
- bimetallic strip thermometers
- electrical digital thermometers
- thermographs.

(2) Automatic temperature recorders should be used in the open air and where there are severe fluctuations in temperature.

(3) the accuracy of reading should be at least 1^{O} C.

b) Performance of the measurements

(1) the measurements should be made in the immediate vicinity of the works.

(2) the temperature sensor should not be exposed to direct solar radiation.

(3) The intervals between measurements must be such that temperature change > 2ºC are detected.

A1.2.9.2. Relative Atmospheric Humidity

a) Apparatus & Instruments

(1) The following instruments may be used to measure relative atmospheric humidity:

- hair hygrometers
- electrical digital hygrometers
- hygrographs.

(2) The accuracy of reading must be at least 1% relative atmospheric humidity (5% relative atmospheric humidity in the case of hygrographs). The instruments must be checked prior to commencement of the work, and adjusted as necessary. For this purpose, the senor is to be wrapped in damp cloths, avoiding any direct moistening. The instrument must then read 95-98% relative atmospheric humidity.

b) Performance of the measurements

The instruments must not be exposed to direct solar radiation.

A1.2.9.3. Component Temperature

a) Apparatus & Instruments

The instruments specified in A1.2.9.1. a) may also be used to measure component temperatures; the use of electrical digital thermometers is preferred.

b) Performance of the measurements

Measurements of surface temperature should preferably be made on components whose temperature may be lower than that of the air, as a result of their position and size, and taking into account the preceding weather conditions. Thermometers with contact sensors must be used. The intervals between measurements must be such that any impending drop in temperature below the dew-point can be detected in good time.

(1) Measurements of temperature in the interior of components must be made in drilled holes with a diameter of approximately 8 mm and a depth of at least 50 mm. The holes must be sealed at the component surface with a heat insulating material.

A1.2.9.4 Dew-Point Temperature

(1) The dew-point temperatures corresponding to the measured air temperatures and relative atmospheric humidities may be taken from standard tables.

(2) The dew-point temperature determined in this way must be compared with the component temperature.

A1.3. Repair Concretes or Mortars

Testing the Inherent Moisture, Surface Moisture and Core Moisture of Aggregate.

(1) Inherent moisture is generally determined by the dehydration test. To determine the surface moisture, it will then generally be sufficient to employ the recommended core moisture values, which are measured during determination of inherent moisture normally vary from 0.5 to 2.2 % depending upon the type of aggregate for 0 to 32 mm aggregate,

(2) The dehydration test is usually made with the samples envisaged for the sieve test, as the aggregates must in any case be dried for sieving.

(3) A quantity of roughly 3500 g is weighed out from an average sample and heated under continuous agitation until the surfaces of the individual grains are dry and the grains no longer adhere to one another. The sample is re-weighed after cooling. The inherent moisture is calculated from the loss in weight by reference to the dried materials.

(4) Para A1.2.4 can be used to determine the surface moisture of aggregate with a maximum grain size of upto 4 mm quickly, and, if used properly, with sufficient accuracy. The larger device holding 200 gm of aggregate is to be preferred, owing to its greater accuracy.

(5) The surface moisture of aggregate of any maximum grain size can also be determined by the flame method, using the AM device. The moist aggregate is weighed and an inflammable liquid is poured over it and ignited. The resulting heat causes the water to evaporate. The difference between the moist and dry weights indicates the water content; the surface moisture is determined by reference to the dry weight.

(6) The Thaulow test provided a further means of determining surface moisture. The core moisture of aggregate with a maximum grain size exceeding 4 mm is determined by immersed storage and subsequent drying of the grain surface. Approximately 1000 g of the relevant grain class is

kept immersed in water for at least 24 hours. The aggregate grains are then dried with a moist cloth and filter paper. The aggregate treated in this way is poured on to a 2 mm sieve and turned while being heated from below by a current of air, for example from a hairdryer or a fan heater, until the surface moisture has apparently dried out. The sample is then weighed to an accuracy of 1 g (mg.k), dehydrated and re-weighed (mg.0d). The difference between the two weights is the core water quantity of the sample. The core moisture is then

$$h_{g,k} = \frac{100(mg.k - mg.0d)}{mg.0d} \quad (M.\%)$$

(7) If the sand is of the same mineral composition as the coarse grains examined, the same core moisture may be assumed.

(8) The same test can be employed to estimate the influence of dry aggregate on the stiffening of green concrete. In this case, however, immersed storage is for 30 minutes only.

A1.4 Surface Protection Systems

A1.4.1. Testing the Thickness of Coatings on a Drilled Core

(1) Small-diameter drilled cores (50 mm or less) are removed. Local changes in layer thickness due to drilling must be taken into account, and where necessary counteracted by appropriate measures. The layer thickness is determined on the surface area, using a measuring magnifier or microscope.

(2) The measurement is not non – destructive, and must therefore be restricted to justified cases, e.g. irregularities during performance of the works. Sections are required in order to determine the exact thickness of thin layers and of sub-layers in multi-layer systems. The work must be entrusted to a specialist laboratory.

9

A1.4.2. Testing Adhesive Strength

a) Terminology

The term adhesive strength denotes the tensile force, which must be applied perpendicular to the coating plane over a defined test area in order to detach a coating from its substrate. This definition means that specimens, which rupture in the substrate concrete or within the coating rather than at the interface may not be taken into account when calculating adhesive strength.

b) Test dies and test equipment

(1) Steel test dies (pulling plates) with a circular bonding face and a diameter of ds=50 mm + 2 mm are employed. The test die must be at last 25 mm in thickness; the thickness remaining below central drillings or recesses must be not less than 15 mm.

(2) The tests may be carried out with portable or fixed tensile strength testing equipment. The measured value must be indicated with a resolution of 2% of the force range being measured. The equipment must possess a device for maintaining a constant loading velocity.

(3) Simpler equipment may be used for internal supervision.

(4) The equipment must be designed in such a way that the tensile force can be applied to the test surface free of shear forces and moments. It must be possible to adjust the equipment above the test die in such a way that the axes of the test die and the working piston are in a straight line.

c) Performance of the tests

(1) The test areas must be selected in such a way that the distances of the test surface edges from one another or from the edge of the component are at least equal to the diameter of the test area.

(2) The test area must be freed of loosely – adhering dirt before the test die is bonded to it. The test surface must be bounded by a ring groove and must be sufficiently dry for bonding.

(3) On hard coatings, the ring groove is drilled wet or dry with a diamond – charged bore-crown. The bore-crown should drill through the coating and penetrate 5 to 10 mm into the concrete. The inside diameter of the ring groove and the outside diameter of the test die must be matched with one another in such a way that the die can be bonded flush to the exposed cylinder. A bore-crown in good cutting condition with rounded cutting edges must be used, to avoid notching of the ring groove root. The exposed cylinder may not be damaged in any way prior to the test. Drilling dust or sludge must be removed thoroughly.

(4) On soft coatings, the test area must be parted through to the concrete after the test die has been bonded on. The cut must be made flush with the circumference of the test die. A sharp knife can be used for cutting.

(5) In general, rapid hardening cold-curing resin adhesives in paste form should be used. The temperature range specified by the manufacturer is to be maintained during the bonding process.

(6) The test die must be placed on the surface in such a way that excess adhesive is pressed out of the joint and air entrapments are avoided. Any adhesive squeezed out of the joint or penetrating into the ring groove must be removed.

(7) After bonding, the die face must be parallel with the test face; the bonding layer must be as thin as possible.

(8) The tensile strength testing machine must be arranged and centred in such a way that the taxes of the test die and the piston lie in a straight line.

(9) On hard coatings, the force should be increased continuously in such a way that the tensile stress in the bonded joint rises by roughly 0.05 N/mm2 per second. For ds = 50 mm, this is equivalent to a force increase of approximately 100 N/s.

(10) On soft coatings, the tensile stress should increase by roughly 0.15 N/mm2 per second. For ds= 50mm, this is equivalent to a force increase of approximately 300 N/s.

d) Evaluation of the results

(1) The visual appearance of the rupture surface is to be evaluated, distinguishing between the following seven cases:

B	-	rupture in the concrete
B/D	-	rupture in the concrete /coating interface
D1/D2	-	rupture in the coating 1/coating 2 interface
D	-	rupture in the coating
D/K	-	rupture in the coating/adhesive interface.
K	-	rupture in the adhesive.
K/S	-	rupture in the adhesive / steel interface.

(2) Only cases B/D and D1/D2 are used in calculating adhesive strength. Supplementary consideration of cases B and D is permitted for estimation of a definitely exceeded adhesive strength in cases where concrete or coating strengths are relatively low.

(3) Where rupture takes place at various levels, the proportions of the different rupture surfaces are to be estimated. The relatively largest component area determines which case the rupture is assigned to.

(4) The adhesive strength is calculated from the maximum attained force F:

$$\beta HZ = \frac{4 \cdot F}{pd^2} \quad (N/mm^2)$$

The adhesive strength must be given to an accuracy of 0.1 N/mm²

e) Test report

The test report must cite:

- the test date
- construction site, component
- position and marking of the test area
- type of coating
- diameter of the test die
- weather conditions during preparation and execution of the tests
- preparation of the test area, type and depth of pre-drilling or cutting
- course of the rupture or description of the parting case
- maximum force and calculated adhesive strength (single values, mean value).
- Where relevant, the definitely exceeded adhesive strength.

A1.4.3 Voids Content of Surface Protection system

(1) At the beginning of, during and at the end of each days work, and at least once for every 250 m² of area treated, sprayed specimens distributed uniformly over the area must be taken. The specimens must be taken under sealant spraying conditions directly at the point of use. The specimens are sprayed onto a foil or plate measuring at least 50 cm x 50 cm, with a thickness of approximately 3 mm.

(2) A small specimen of the hardened coating material is cut out of the sprayed specimen and placed in a material – specific test liquid (corresponding to the density for the value Hmax determined in the basic test minus 3% absolute; the test liquid is supplied by the manufacturer).

(3) The specimen piece must sink immediately to the bottom of the test vessel (e.g. 1 glass cylinder with measuring scale). If the specimen piece does not fall to the bottom, the test must be repeated with a number of specimen pieces. If the result remains the same, the precise value of the actual voids content must be determined.

(4) The mean value of the 3 single measurements must not exceed the maximum voids content Hmax established in the basic test.

A1.4.4. Grid Test with Tape Test

(1) The coating under test and its substrate should have largely smooth surfaces. Textured shells and rough sawn shuttering without filling are unsuitable.

(2) At each measuring point, 4 cuts perpendicular to one another are made with Cutter, so that a grid with 9 squares are produced. The distance between the parallel cuts should be 4 mm. After the grid has been cut, the measuring point is assessed according to the grid test parameters.

(3) A commercial transparent adhesive tape with a width of 30 mm is then applied to the grid made for the grid test, keeping the pressure as even as possible (with a finger or a soft rubber roller), and is pulled off sharply after roughly 1 minute (tape test).

(4) Following each individual test (grid test plus tape test) the measuring point is assessed with the aid of an illuminated magnifier (magnification 6x) according to the grid test parameters.

A1.5. Treatment of Cracks

A1.5.1 Testing the Degree of Crack-Filling on Drilled Cores

(1) Drilled cores provide the only reliable means of determining the completeness of filling. A check should therefore be made only in justified cases, i.e. where there have been irregularities during execution of the works where faults in the filling are visible externally.

(2) Small-diameter drilled cores (50mm or less) are taken from characteristic sections of the filled cracks. The degree of crack-filling is determined from the visual appearance of the drilled core surface, where necessary with the aid of a magnifier or a microscope.

(3) the crack width and the lengths of the filled and un-filled sections of the cracks are determined on the surface of the drilled core.

Providing & applied polyurethane hybrid roof topcoat water proof coating with flutyne technology to resist water intrusion & heat & highly elastic, seamless membrane that provides excellent protection from moisture and is resisting to ponding water. It should be exhibits excellent resistance to UV radiation and thermal aging.it includes 45 GSM Glass reinforced fibre mesh waterproofing membrane plain finished which consist a coat of primer for membrane of M/s CICO Technologies Ltd, SIKA/ FOSROC/Dr. Fixit as per manufacturers specifications to horizontal RCC roof terraces at all levels and part of parapet (upto 300 mm height returns/wattas) including neat clean the surface, crack filling with water proofing agent, cutting groove and forming drip mould with the joint of parapet wall plaster at height of minimum 300 mm from finished waterproof roof surface and at uniform level all along the parapet/vertical wall on tarrace or toilet block floor with ultra violet resistance. The waterproofing shall be done at sunk slab or on terrace up to any height with all lead and lift .The waterproofing should have minimum 5 years of guarantee bond on stamp paper of Rs. 300 against any leakage.etc complete as directed by engineer in charge.

Standard Compliance / Specification

The coat surpasses the ASTM D 6083-TType I standard specification, offering exceptional waterproofing and long-term durability.

Methods of Application

1 SURFACE PREPARATION :

- The terrace roof must be cleaned with stiff nylon and wire brushing, followed by high-pressure water jet cleaning. Algae and fungus on the parapet walls and terrace roof shall be treated with a fungicidal solution.
- Freshly laid cement-sand concrete screed should be designed to be greater than 80 mm thick and have a 50 mm thickness at the end slope. Allow the concrete to complete a wet and dry cure for 8 weeks before applying the top coat coating.
- Mechanical methods like grinding are recommended to enhance the adhesion and bonding of coatings to smooth, fresh concrete surfaces to remove contaminants, laitance, and existing coatings.
- For a full roof repair, according to IS 456-2000, the minimum grade of concrete screed should be M25 or M20 with a maximum free water-to-cement ratio of 0.5 and a minimum cement content of 300 kg/m3. This screed should be admixed with Integral waterproofing liquid LW+ and 12 mm and 6 mm micro polypropylene fibers.
- Make sure that the roof slope is at least 1 in 80 or 1 in 100, as per the specified requirements.
- Remove concrete screed, brickbat coba, China mosaic, or ceramic tiles if they are found to be debonded by more than 30% from the roof substrate during a hammer test. Proceed to reach up to the base slab level for fresh waterproofing as necessary.
- Thoroughly inspect the terrace roof for cracks, blisters, ponding, exposed foam, and open seams. Evaluate the debonding of screeds or tiles on the terrace roof by tapping with a nylon hammer. Give special attention to areas around roof penetrations, ponding spots, and parapet wall cracks.
- Ensure there is a single water drain outlet of at least 100 mm in diameter for a 500-square-foot floor area, and gaps around pipe inserts should be sealed properly with polymer-modified mortar.
- Stagnant water caused by undulations in the roof surface should be identified and repaired using Polymer- Modified Mortar (PMM).
- All joints / corners / penetration points, rainwater outlets, marble / tile strip joints should

be grouted with polymer modified mortar.
- Ensure that all penetration points, mechanical equipment, HVAC & solar panels are suitably placed.

SCREED REPAIR:

- Remove loose and damaged / hollow sound concrete roof screed in pockets with mechanical cutter.
- Clean the concrete screed with water to remove dirt and loose particles.
- Brush applies a bond coat of SBR based polymer & cement mixed in the ratio of 1:1 (SBR polymer 1: Cement 1 by volume to make it lump free slurry coat. Repair the damaged concrete screed surface with Polymer Modified Mortar mixed with SBR based polymer 10% by weight of cement in (M20) concrete in ratio of 1:1.5:3 i.e., one bag of 50kg cements: 1.5 times volume of sand: 3 times volume of aggregates: 25L water.
- Level the repair mortar and finish with trowel by providing proper slope. Moist cures the repaired surface for 7 days. Air cure screed for 4-5 days, before application of roof topcoat coating system.

TREATMENT OF ROOF WITH STAGNANT WATER:

- Make the surface rough by hacking and chipping out the undulations portion. Extend it on the larger area to create slop towards drain.
- Apply a bond coat of URP mix in the ratio of 1:1 (URP 1: Cement 1) by volume to make it lump free slurry when applied on in the pre wet surface.
- Prepare the Polymer modified mortar (PMM) mixing with URP 10% by weight of cement in the ratio of 1:3 when the bond coat is tacky, finishing with trowel. Moist wet curing must be done up to 3-4 days.

SCREED CRACK REPAIR:

- All visible hairline cracks on concrete roof screed > 0.50 mm and not giving hollow sound, should be cut and widen in V shape with mechanical cutter in the size (10mm W x 6mm D) and filling the same with Hybrid / PU sealant with suitable gun.
- Allow sealant to cure a minimum 72 hours (about 3 days).
- Apply a bandage of Roof seal Ultra in 2 coats reinforce with 45 GSM glass fiber mesh over and above the crack repair surface in the length of crack.

RAINWATER OUTLETS TREATMENT:

- Hacking and chipping the surface around the rainwater drain outlet mouth up to 25mm in depth.
- Apply a bond coat of SBR based polymer URP & cement mixed in the ratio of 1:1 (polymer 1: Cement 1) by volume over the corners and pipe insert outlet gaps. Filling the gaps around drain mouth with (PMM) polymer modified mortar mixed with 10% by weight of cement in the ratio of 1:3.
  Providing & fixing 100 mm width 45gsm glass fiber mesh all around the periphery of drain mouth of rainwater outlet sandwiched with Roof seal Ultra waterproof coating.
  Apply the second coat on an interval of 4-6 hours, all over the rainwater outlet.

VERTICAL UP STAND DETAILING:

- Providing 100mm x 100 mm Square / rectangle up-stand of M20 grade concrete or with Polymer Modified mortar around mechanical equipment like HVAC, air-conditioning, solar panels. Etc.
- Apply 2 coats of Roof seal Ultra dilute without water dilution sandwiched with 45 Gsm glass fiber mesh in the interval of 4 -6 hrs. Ensure that all the reinforcement is properly placed and embedded with material.

2 WATERPROOFING APPLICATION

- Dilute 2 parts of Prime seal with 1 part of water to cover 8 sq. m. Allow the primer coat to dry for 6 to 8 hours.
- Stir well before using. Apply the 1st coat of Roof seal Ultra waterproof coating without dilution at a rate of 0.70-0.75 liters per sq. m. per coat.
- Lay down a 45 GSM fiber glass mesh into the coating as a sandwich layer while the first coat is still wet.
- Second coat application: Allow the first coat to dry for approximately 4-6 hours before applying the second coat at a 90° angle to the first coat.
- Apply the second coat of Roof seal Ultra waterproof coating without dilution at a rate of 0.70-0.75 liters per sq. m. per coat, ensuring total material consumption of 1.40–1.50 liters per sq. m. in 2-3 coats.
- Ensure there are no pinholes or air bubbles on the membrane.

Allow the system to air cure for a minimum of 7 days.

FOR VERTICAL WALL AND PARAPET WALL SURFACES

Apply the Raincoat Classic / Select external wall coating system on vertical surface and parapet wall for complete waterproofing of terrace roofs.

3 MAINTENAN CE & RECOATIN G

- If Roof seal Ultra coating develops cracks due to weathering or temperature variations over time, it can be easily repaired. Simply cut any cracks into a V-groove up to 8mm in width and depth and fill them with PU / hybrid sealant. Allow the sealant to air cure for 72 hrs, then place a 45-gsm glass fiber mesh over length of crack and apply with Roof seal Ultra. Apply the second coat after the interval of 4-6 hrs ensuring no void areas are left uncoated with the second coat.

4 POST APPLICATIO N

let the waterproofing cure for at least 7 days before you proceed with your flood / pond testing by ponding water up to 50mm height for 24 hrs.

5 D RYIN G/ CURING TIME AT 30^0 C/ 85 % RH

Touch Dry – 60 min.

Hard Dry – 5 to 6 hours.

Drying times may vary depending on the prevailing climatic conditions; low temperature and higher relative humidity may prolong the drying process.

6 TOOLS CLEAN - UP

Brush & Roller can be cleaned up with water while it is still wet.

Precautions & Limitations

All corners, gaps, joints, Roof leak repair area & outlets shall be coated with two extra coats.

Do not apply if rain is expected within 48 hours after application.

The product is designed only for foot traffic and not vehicular or movement of machinery or equipment.

Do not apply Roof seal Select over expansion or moving joints.

To achieve the full proof waterproofing, parapet walls should be covered with Raincoat.

Roof seal Ultra is recommended over existing building Flat/ Slope roof surface like

Brick-Bat Coba finish, Screed China mosaic roof tile surface, Clay tile roof. Apply Primer AC for application on non- porous surfaces like Marble, Granite, glazed ceramic tiles surfaces not recommend for application on Kota, & kadappa stone tiles and mud phuska roof, and over mangalore tile surface.

Do not apply when ambient temperature is below 10°C or above 36°C.

Keep the material in close when not in use.

Technical Information

PROPERTIES	UNIT	TEST METHOD	RESULTS
Solid Content	%	ASTM D1644	69□ 2
Density	(gm/cc)	ASTM D 1475	1.43
Elongation at Break □	%	ASTM D 412	300
Tensile Strength with 45 Gsm	N/mm^2	ASTM D 412	4
Pull off Adhesion	N/mm^2	ASTM D 4541	1.8
Shore A Hardness	Values	ASTM D 2240	72
Crack Bridging Ability	mm	EN 1062 -7	3
Water Vapour transmission	$g/m^2/day$	ASTM E 96	26
Tear Resistance with 45 Gsm GF	K/Nm	ASTM D 624	69
Water immersation test	Visual	ISO 2812- 2	Resistant
Dry Film Thickness	µ	EN 1062 -1	950

Test Conducted	**Test method**	**Specification as per**	**Test results**
Solid Content w/s %	ASTM D 1644	> 60	69 ± 2
Stormer Viscosity @23 °C KU	ASTM D 562	80 -145	128
Initial Elongation at Break □ %	ASTM D 2370	Min. 100	300
Tensile Strength N/mm^2 with GF	ASTM D 2370	Min 1.4	4
Permeance	ASTM D 1653	Max 50	26
Peal Adhesion to Concrete N/m^2	ASTM D 903	Min 350	475
Adhesion to Aluminum N/m^2	ASTMD C 794	Min 350	430
Adhesion to Mortar N/m^2	ASTMD C 794	Min 350	450
Adhesion to Glass N/m^2	ASTMD C 794	Min 350	380
Low temperature flexibility after 1000 Hrs. accelerated weathering	ASTM D 522	Min Pass 13 mm mandrel @ 10 °C	Pass
Final Elongation after 1000 Hrs. Accelerated weathering	ASTM D 2370	Min 100 %	130
Accelerated weathering 1000 Hrs.	ASTM D 4798	Visual	No Cracking
Fungi resistance	ASTM G 21	Zero Rating	Zero
Tear resistance K/Nm	ASTMD 624	>21	25
Tear resistance K/Nm with GF mesh	ASTMD 624	>21	69
Water swelling %	ASTM D 471	Max 20	0.2
Shore A Hardness	ASTM D 2240	Value	72

Crack bridging ability mm	ASTM C 1305	Visual	Pass - No sign of cracking, Splitting and pinholes
Resistance to Fire	ASTM E	Spread of Flame	Class A
Adhesion to Concrete N/mm2	ASTM D 4541		1.8
SRI Index	ASTM E 1980-01		104-106
Water permeability @5 bar	EN 12390-8		Nil

The values in the above table are obtained in controlled lab conditions when tested properly by competent laboratory.

Note: Tolerance up to 5 % on the lower side from the above values is allowable.

Theoretical Coverage*

Consumption at the rate 1.40- 1.50 / Litre Sq.mt in 2-3 heavy coats to achieve dry film thickness of 900 to 1000 microns.

*Coverage may vary based on surface conditions and the application method. Additional material may be needed to achieve the desired dry film thickness (DFT).