

## Training Requirements in 3 R's highlight the Gaps in Knowledge of Professional Engineers

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### 1.0 Introduction

The construction industry of the subcontinent, as it stands today, deals with multiple kinds of civil structures such as masonry units, RCC buildings, bridges, dams, industrial hubs, monumental structures and so on. Contrary to growing new infrastructures meeting the needs of the burgeoning population of the country, a significant number of India's built up structures also erode with age, neglect, misuse, pollution and varying climatic conditions prevailing in the country. Professionals in the field of construction are therefore face the challenges of leading the future development as well as ensuring structural renewal and durability of the structures through Repair, Restoration and Renewal engineering (3R's) methods. But reliable statistics of arresting such structural damages are not readily available though the distresses are visible in all parts of the country. Hence, knowledge on renewal engineering, in general is turning out to be a critical issue for the construction professionals encompassing residential, commercial, industrial and infrastructural segments.

### 2.0 Need of Repair, Restoration and Renewal Engineering (3R's)

Let us first understand the meaning of 3R's-

Repair mean restoring a structure to a good or sound condition after its decay or damage. Restoration means the act of restoring or returning to a normal or healthy condition of concrete structure as before. Renewal Engineering means renovation or restoration of a structure with the creative application of scientific principles engineering practices to design or develop the structures.

Construction of a structure also deals with numerous activities and engineering practices. Now, any project involves various entities like the client, the architect, structural Engineers, contractor, sub-contractor and suppliers, involving varying workmanship and skills of construction workers.

Since independence, the construction activity has been increasing but there is hardly any increase in availability of matching inputs, in terms of materials and skilled workmen. This gap contributed to the damages and distresses in buildings right from construction stage concealed under the external plaster and paint. Apart from these, the factors that also affect the structures and

lead to damages are poor design, inferior construction materials, wrong construction practices, and damages due to indiscriminate additions or alterations, natural calamities, overloading and external factors like environmental stresses, industrial wastes, pollution, and high humidity.

The above factors stimulated by conventional construction practices lead to formation of cracks, leakages, seepages, corrosion of steel, spalling of concrete, etc, ultimately affecting the durability of the structures. Then, to protect the structures, Repair, Restoration and Renewal engineering (3R's) methods are adopted in different periods of its life cycle depending on the extent of concrete deterioration. But such methods under 3R involve a substantial amount of money in a periodic way and failure of repairs multiply the costs in higher folds, affecting the economy of the nation in a broader sense.

In India, due to unorganized nature of the construction and repair industry and outdated methods of execution, the performance of repair can be vaguely shown as under.

This performance will further get affected depending on the aggressive conditions varying from region to region in India. More recently, the widespread deterioration of our infrastructure and the high cost of replacement give us no option but to repair and rehabilitate.

### 3.0 Gaps in Construction and Knowledge of Professional Engineers

New construction and repair works differ from each other in several important aspects including project scale, technology management and financing. The approved and adopted repair strategy will not yield any good result unless the major source of deterioration is not addressed in the planning. The knowledge of practicing engineers in this field has gaps in conventional and new technologies about which, how, what, where these technologies to be used. Following are the gaps such as:

- Lack of advanced diagnostic techniques
- Availability of code of practices on waterproofing, repairs and maintenance of concrete structures.
- Specifications requirements
- Knowledge of repair materials
- Application methodologies

#### 3.1 Lack of Advanced Diagnostic Techniques

As any disease requires a proper clinical investigation before its treatment, similarly, structural diagnosis implies to diagnose the root cause of defects in the concrete structure by adopting right diagnostic

methods. When the structure (old or new) lacks to perform, it immediately affects its structural and aesthetic view, weakening of structural members (columns, beams, slabs etc.), penetration of water showing patches of dampness and leakage, cracks on external and internal walls, spalling of concrete, etc. For diagnostic interpretation of these problems, engineers mostly follow conventional methods and routine nondestructive tests using only Rebound Hammer, Ultrasonic Pulse Velocity test, and Half Cell Potential test resulting in inadequate data and improper diagnosis. The effective repair should involve advanced diagnostic methods such as Liquid Leakage Detector, Infrared Thermography, and Petrography, Corrosion Analyzer, etc, to find out the root cause and extent of leakages and damage along with after NDT methods. Professional engineers are not aware of these diagnostic methods which lead to diagnostic gap in this repair field.

### 3.2 Availability of Code of Practices

Till date, Indian code of Practice is limited to bitumen based material for waterproofing and unfortunately, no code of practice for concrete repairs and maintenance of concrete structures are available under BIS. Most of our specifications and material applications then have to follow the standards like British Standards (BS), ASTM, DIN, European (EN), and Australian standards. As professional engineers, designers, contractors and owners are not acquainted with these international standards, repair works suffers at the project site.

### 3.3 Specifications Requirements:

Repair works should follow a detailed specification given by the engineers as per codes and standards. These specifications deal with work procedure, application of materials handling, manpower etc. The industry normally follows the manufacturer's specifications on materials and methodology following the British and European codes where performance evaluation is based upon their climatic conditions. We do not go into the depth to find out whether these standard tests are representative of field conditions in India, and hence they are mistakenly used to determine durability criteria for field use. Moreover, the development of performance standards is not at par with the development of materials, primarily because of lack of supporting scientific and field data. All these ultimately lead to a high failure rate with new technologies and materials in our country.

### 3.4 Knowledge of Repair Materials

Today, though a plethora of materials are available for repair of structures; the common practice among engineers is to go ahead with the age-old conventional methods. This is attributed to ignorance in knowledge on material science and their applicability areas. A list of polymeric materials which are available in the industry is given below:

- Polymeric cementitious materials
- Ready to use repair materials
- Pre packed mortars
- Protective coatings
- Waterproof coatings
- Bonding agents, etc.

Concrete repair requires materials with different physical and chemical properties depending on extent of damage and the compatibility with the original construction material. Moreover, the repair material should meet durability requirements of concrete structures. The correct choice and proper use of repair materials is therefore, critical to the achievement of long service life for repaired structures.

### 3.5 Application Methodologies

Repair, restoration and renewal engineering (3R) should be carried out with engineered repair materials, standard procedures and skilled applications. The use of proper procedures in repair, restoration is critical to success; but unfortunately these procedures are not well defined by codes and standards as those for new construction. The different application techniques are followed such as:

- Guniting
- Shotcreting
- Patch repairs
- Injection grouting
- Jacketing or encasement
- Structural strengthening by fiber reinforced wrapping
- Ready mix mortar repair
- Integral crystalline repairs, etc.

Added to these are advanced techniques which are sometimes innovated to carry out repair works at normal and inaccessible areas. As a result, engineers at the site carry out repair works with conventional methods which are not adequate for durable repairs. Eventually, high incidences of repair failure occur at the site and often the repairs have to be re-done within a short period which is an enormously costly exercise.

### 3.6 Other issues

Engineers responsible for selection will be expected to exercise social responsibility by considering not only engineering properties and cost, but also ecological friendliness.

#### 3.6.1 Health & Safety

The growing importance of health and safety issues requires upgrading of the structure in such a way that it meets current fire codes and air quality requirements. This will entail the use of materials with good fire-retardant characteristics and innocuous

materials free of toxic emissions.

### 3.6.2 Laboratory testing

The use of performance specifications will encourage innovation and will facilitate the linking of laboratory and field data with field performance. However, this will require a better understanding of the relationship between material composition, microstructure and physical performance. Concrete durability is becoming the single most important design criterion in new codes in places such as Japan, Australia and Europe.

### 3.6.3 Lack of knowledge of maintenance

Maintenance of structures is one of the very important and key parameters to maintain the structure in a good condition. For betterment, everybody maintains their health with their living lifestyles. Similarly, for a good and a healthy structure, it should be maintained with different maintenance schedules and patterns.

### 4.0 Personnel Training for 3 R's

Repair, Restoration and Renewal engineering works requires skilled, semi-skilled and expertise manpower. To carry out extremely sensitive and important operations in repair works, training should be given to the personnel for successful repair works.

Various improvements that need to be included should result in reducing -

- Repair mistakes
- Miscalculations
- Poor performance of materials
- Poor workmanship
- Finding better repair method- that reduces costs while improving quality.

Goal oriented training helps the industry, comprising of Government and private organizations, research institutes and educational facilities, to accelerate qualitative progress in the repair industry such as

- Usage of performance-based guide specifications for specific and generic repair designs to improve specifications.
- Improved repair material design and performance to eliminate cracking, to carry structural loads and to have set and cure properties established by the construction process.
- Usage of environmentally and worker- friendly repair methods, equipment, and materials that will greatly reduce the adverse effects on workers, the public and the earth's ecosystem.
- Developing selection processes, contractual agreements, procurement methods and relationship arrangements (partnering) that will greatly reduce conflicts, rework, and claims, lawsuits resulting from disagreements

among contractors, general contractors, engineers and owners.

- Developing facility owner education that will promote awareness of the effects of deterioration and the means to reduce the risks while protecting their investments.
- Developing improved means and methods for accurate and thorough condition assessment.
- Usage of specific repair system for expanded use, efficiency, and failure reductions.

### 5.0 Professional Courses:

To overcome all over these gaps in the knowledge of professional engineers in this field and training needs in 3 R's, there are only some institutes conducting various courses in this field in India such as

- Dr. Fixit Institute of Structural Protection and Rehabilitation (DFI-SPR) conducts various training programmes on "Construction chemicals applications", "Waterproofing Materials, Systems and Technologies", "Corrosion and Protective Coatings", "Structural Diagnosis and Condition Assessment of RC Structures" etc., and a certificate course on "Entrepreneurship in Waterproofing, Structural Protection and Repair of Concrete Structures" for civil engineers, contractors, builders, site engineers etc. Special lecture on "Waterproofing and Repairs of Concrete Structures" for civil engineering students.
- National Institute of Construction Management and Research, (NICMAR) Pune, conducts distance education programme for six months and one year post graduate programme on "Concrete Technology Waterproofing and Repair Management".
- Mumbai University, Maharashtra in Civil Engineering. Undergraduate courses offers elective subjects in seventh and eighth semester on "Reinforced Concrete Repairs and Maintenance" and "Advanced Repair and Rehabilitation of Structures" respectively.
- Annamalai University, Tamilnadu offers a distance education programme for one year diploma course in "Damage Assessment, Repair and Rehabilitation of Structures."
- Indira Gandhi National Open University (IGNOU), New Delhi offers a distance education programme for one year diploma course in "Construction Supervision and Building maintenance."
- Yashwantrao Chavan Maharashtra Open University (YCMOU), Nashik- offers a distance education programme as a certificate programme in "Fire and Safety Engineering and Management".
- Central Building Research Institute (CBRI), Institution of Engineers India, (IEI), Indian Institute of Technology (IIT)'s, Construction Industry

Development Council (CIDC), Building Materials and Technology Promotion Council (BMTPC) conduct special lectures, seminars and conferences and training programmes on Repair, Restoration and Rehabilitation of concrete structures.

- International Concrete Repair Institute (ICRI), American Concrete Institute (ACI), publishes concrete repair guidelines and research papers.

## 6.0 Conclusion:

- A repair project is more specialized, and good site management and construction practices have to be followed. The construction industry must make every effort to solve the problems that are inherent in the use of current materials and technologies.
- The assessment, design and implementation of repairs to existing structures are more complex than newly constructing them. Therefore, the gaps in construction and repair work practices should be bridged with new materials and advanced techniques, effectively through training on 3R's for professional engineers.
- The Repair industry has several beneficiaries like engineers, architects, equipment suppliers, material manufacturers, researchers, educators, testing companies, contractors, and lawyers. As a matter of fact, all these beneficiaries, along with owners,

become stake holders and are thus obliged to put up their best foot forward and their expertise and be in ready to accept the other person's expertise for a common interest.

- With the right focus on the causes, evaluation and selection of correct repair materials; the resultant repairs would be long lasting and we would be able to avoid expensive repetitions of repairs in the future.
- The future prospects of the repair industry are based on an understanding of current trends in looking both opportunities and problems. Creative technology-based responses to the infrastructure problems would ideally take the form of improvements in the productivity of repair and rehabilitation activities, durability, and predictability and less expensive repairs.

## References

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