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Special Materials for Rehabilitation of Monuments

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***Abstract*- Monuments have been created for thousands of years and they are often the most durable and famous symbols of ancient civilizations. These are the icons of the nation having their own cultural and historic values therefore, it is very essential to conserve them.Each monument has its special design and decorative finishes and its own peculiar conservation problems which need innovative solutions. The deterioration of the structures takes place due to pollution, weathering action, fire, natural calamities like earthquake, flood, tsunami, cyclones, soil and structure interaction (Settlement of soil etc.), defects in construction and many more. This is going to be a great loss for the nation as the monuments are the importantlandmarks of the nation.Depending upon the look of the parent structure it is necessary to select the right material for the rehabilitation. New material should be compatible to the existing material in the structure. This paper will help to know the available materials that can be adopted for the rehabilitation of the monuments so that its aesthetic look is not changed.**

Keywords—Monument, Rehabilitation, FRP,Epoxy,Wood preservative, Waterproofing agents.

I. INTRODUCTION

The term 'Monument' is often applied to buildings or structures that are considered examples of important architectural and/or cultural heritage. Monuments have been created for thousands of years and they are often the most durable and famous symbols of ancient civilizations. These are the icons of the nation having their own cultural and historic values therefore, it is very essential to conserve them.Monuments which have no further utilization tend to decay rapidly, while which are still in use have a better chance of being maintained.

Rehabilitation involves contribution of high end technology, advanced skills and calculations. This is a very responsible job of saving hazardous failure of structures due to deterioration. The success in rehabilitating the structure totallydepends on gaining expertise in the field and day to day advancements. Rehabilitation is highly recommended for age-old buildings showing signs of decay and save human lives from failures.

As the degradation of these monuments takes place due to various reasons, it is necessary to rehabilitate thembefore its failure. But care should be taken that the aesthetic of the monument should not be changed. To achieve this, the material and technique to be used should be carefully adopted. The systematic approach to deteriorated structure is necessary. Also there should be a balance betweenmanagement, technology and economics. The engineer in-charge of rehabilitation should have qualities of an investigator, structural designer, material technologist and awareness of application techniques.

II. NECESSITY OF REHABILITATION

Monuments have their own cultural and historic values. The deterioration of these structures takes place due to pollution, weathering action, fire, natural calamities like earthquake, flood, tsunami, cyclones, soil and structure interaction (Settlement of soil etc.), defects in construction and many more. This is going to be a great loss for the nation as the monuments are the icons of the nation.

The need for structural rehabilitation of heritage buildings is usually motivated by one or more of the following circumstances:
(1) Visible defects in the building;
(2) Damage after a particular event (earthquake, etc.);
(3) The change of the use of the building; and
(4) Requirement of the competent authority, for instance, when there is an increase in the actions (earthquake action, traffic action, etc.) imposed by new codes.

Before executing the rehabilitation, investigation of the structure should be carried out. Proper assessment of the structure is a complex task.In the assessment, physical, chemical and mechanical properties of the stones and mortars and all materials used in the structure is determined which sheds light on the constructional techniques, architectural forms and material used in the original building. Depending upon this information one should be able to select a compatible material for the rehabilitation.

III. HERITAGE ACTS IN GENERAL

Heritage structures and sites are classified as Grade I, II and III indescending order of importance. Development permission for changes in any of these would be given on the advice of the Heritage Conservation Committee.

Grade I structures and precincts are of national and historic importance having their own architectural style, design, technology and material usage and/or aesthetics. They may be associated with a great historic event, personality, movement or institution. For these grade I structures no intervention either exterior or interior is allowed unless it is necessary in the interest of strengthening and prolonging the life of those structure or precincts.

Grade II structures and precincts are of regional or local importance possessing special architectural or aesthetic merit, or cultural or historical significance though of a lower scale than Heritage Grade-I. Internal changes and adaptive re-use may be allowed but subject to strict scrutiny.

Grade-III structures and precincts are of importance for townscape; that evoke architectural, aesthetic, or sociological interest through not as much as in Heritage Grade II. Internal or external changes can be allowed but with preserving their unique features properly.

IV. SPECIAL MATERIALS:

New innovations, upgraded systems, improved technologies, advances in the construction industry are constantly evolving. The engineers should be aware of these changes and should also know what is up-coming in their field. Following are some special materials which can be used for the rehabilitation of the monuments:

A. Epoxy resins
B. Fiber Reinforced Polymers (FRP)

C. Water proofing agents:
- Acrylic polymers,
- SBR,
- EPDM,
- APP

D. Wood preservatives and coatings:
- Chromated copper arsenate,
- Ammonical copper quanternary,
- Copper azole,
- Boron,
- Creosote.

A) Epoxy resins:

It can be used for high performance coating, flooring grouting, adhesive or injection systems in concrete, wood, brick, metal and many other materials. Demand for the epoxy resin is growing rapidly because of the properties like good mechanical strength, chemical resistance and ease of working. The extreme versatility of these resin formulations has led to their widespread use in the constructional industries of many countries. The simple mixing and polymerization methods involved enable them to be used easily on site.

For the monuments, it is a very good grouting material than cement grouts, as it gives good strength to the structural members.

Fig.1 Wrapping of FRP.

B) Fiber Reinforced Polymers (FRP):

FRP sheets are wrapped around the columns, with fibers oriented perpendicular to the longitudinal axis of column and are fixed to the column using epoxy resin. It is easy to install like putting up wallpapers.

The original size, shape and weight of the member remain unaltered (unlike any other jacketing method) therefore; this method is particularly useful for strengthening historic and artistic masonry structures. FRP provides minimum disturbance to the existing structure. The strengthening work can be performed with normal functioning of structure.

C) Water proofing agents:

- Acrylic polymers: The acrylics are widely used as coatings, binders etc. Due to their outstanding properties as color stability, transparency, and resistance to weathering and aging these are accepted widely in the market. These polymers have good weathering resistance as they resists hydrolysis. Also it does not absorb ultraviolet light which is most responsible for degradation.

  It requires low temperature at application, it does not have corrosion resistance property.

- SBR (Styrene-Butadiene Rubber): SBR resists the water penetration and capillary absorption into the concrete/mortar. It acts as anti-corrosive for steel.It is non-flammable & non-hazardous. Also it does not evolve toxic gases when exposed to fire. It is Non-toxic to human being and a good resistant to fungus and micro-organism growth.

  It can't be stored in heat for long time. It is compatible with only OPC with sulphate resisting and high alumina cements.

- EPDM (Ethylene propylene dienemonomer): EPDM membrane is a lightweight, durable and weatherproof single-ply waterproofing membrane perfect for a wide variety of applications. For more than 20 years, it is proven that it can withstand extreme temperature fluctuations and constant exposure to direct sunlight. Also, it has exceptional elasticity and will not split or crack under normal building movement.

- APP (Atactic Polypropylene polymer): It is used as waterproofing /damp proofing membrane. It is capable of withstanding thermal and structural stresses. It has excellent water tightness and very easy to apply.

D) Wood preservatives and coatings:

- Chromate copper arsenate:It is a preservative that has no limitations. The copper and arsenic are the fungicide and insecticide respectively, while chromium fixes the chemical to the wood. The chemical penetrates the wood well, is odorless and surfaces can be painted once dried.
- Ammoniacal copper quaternary:The different formulations of ACQ allow some flexibility in achieving compatibility with a specific wood species and application. An ammonia carrier in ACQ improves the ability of ACQ to penetrate into wood that is difficult to treat.

  ACQ treatments accelerate corrosion of metal fasteners.
- Copper azoles:Copper azoles are another preservative formulations that relies primarily on amine copper, but with additional biocides, to protect wood from decay and insect attack. Wood treated with copper azoles formulation has a greenish-brown color and little or no odor.

  Copper azole treatments increase the rate of corrosion of metal fasteners relative to untreated wood. So should be used with great care.
- Boron:Wood treated with borates has no added color, no odor and can be finished. These are effective against fungi and most insects with low mammalian toxicity.

  It can only be used in low hazard environment such as house framing.
- Creosote:Creosote is toxic to fungi and insects, is relatively insoluble in water and is generally low cost.

  The pungent odor, oily finish and its propensity to leak and stain surrounding material make it less desirable in some situations.Creosote-treated wood is very difficult to paint.

Numbers of materials and techniques are available in the market now. Each material is having different properties than the other materials. Numbers of chemicals are available with their different contents and different properties. But before using them, one should check the compatibility of the new materials with old materials otherwise it will be hazardous for the structure.

Fig. 2TheHirshhorn Museum of art building

A very good example of failure due to use of non-compatible materials, is rehabilitation of The Hirshhorn Museum of art building (U.S.), which is explained by Mr. Boyd[1] in his research paper.

In1993, in this building, certain crack began to enlarge due to the leakages in the building members. It was decided to use the method of pressure injection with epoxy but number of attempts disappointed the engineers. Epoxy has been found to penetrate only to a shallow depth where the epoxy can penetrate to any degree and any moisture content within the crack. Then the alternate method of vacuum technology was adopted.

Therefore the real challenge before us is to plan the necessary measures of conservation. Engineers should rehabilitate the heritage buildings with as little intervention as possible but without altering or modifying in any way the authenticity of their original characters. And this cultural heritage and unique symbols of our civilizations should survive for centuries with us.

V. MAINTENANCE

For the monument, only rehabilitation is not sufficient to protect its own cultural and historic values, but regular maintenance is very important for its longer life. Maintenance is the routine work which is necessary to protect the monument'sunique fabric, its design etc. All building materials decay eventually due to sunlight, rain and wind, and therefore they require continued attention if a building's condition is to be maintained. Periodic inspection is very essential which helps to find out any damage to the members or components of the structure and therefore the structure can be protected longer by adopting time to time repair works.

VI. CONCLUSION

For the rehabilitation of any heritage structure or monument, first of all the Grade of the building should be taken into account. Depending upon the Grade of that structure, the rehabilitation program should be planned with the permission of Heritage Conservation Committee.

Secondly, engineers should be aware of the materials available in the market. Engineers should select proper material and technique for the rehabilitation of the particular monument so that its aesthetic look is not changed. Properties of the old materials and new should match each other. All conditions of using the new materials should be suitable.

For strengthening of members materials like FRP can be useful rather using jacketing of the members. Epoxy can be used for better strengthening instead of using cementitious grout. While using these materials or techniques, compatibility of the new materials with old materials should be checked properly. And a periodic maintenance should be adopted.

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