# ReBuild

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A Quarterly Newsletter

## PRESEREVATION, REHABILITATION AND RESTORATION OF HISTORIC STRUCTURES

Dr. Fixit Institute
of Structural Protection & Rehabilitation

A Not-for-Profit Knowledge Centre

## Preserevation,Rehabilitation and Restoration of Historic Structures

India, being a land of rich cultural heritage, is a treasure house of historic buildings and monuments. We are all aware that as many as 26 cultural and natural sites in India have been included in the World Heritage listing by UNESCO. In addition, until 2005 approximately 67,000 listings covering 200 places and 25 states in India wee completed outside the World Heritage listing. While the Archeological Survey of India is responsible for preserving designated ancient monuments of national importance, another non-governmental organization INTACH (The Indian National Trust for Art and Cultural Heritage) is more extensively dedicated to preservation and conservation of heritage sites.

In a comprehensive approach, one has to look at the potential of "preservation", "rehabilitation", and "restoration" of historic structures. "Preservation" involves maintaining and stabilizing the existing form and integrity of a historical structure so as to protect its heritage value. "Rehabilitation", on the other hand, entails making possible a continuing or compatible contemporary use of a historic building through repair, alterations and additions, while protecting its heritage value. So far as "restoration" is concerned, it refers to making a historic structure reflect its original state as it appeared at a particular period in its history.

All these modes of conservation demand a very rational and scientific approach which starts with a study of structural integrity, and takes the course of determining the causes of deterioration, planning the corresponding remedial measures, selecting compatible repair and restoration materials, site planning in consonance with end objectives and meticulous execution with the help of qualified contractors. On the whole, conservation involves intervention at various levels that are determined by the physical conditions, the causes of deterioration and the on-going needs of the place and surroundings. By and large, a policy of minimal intervention is generally desirable. Further, the settings of heritage buildings are often of great relevance and, therefore, buildings alone are not considered in isolation. The environs of a heritage building can be extensive and may include boundary walls, pathways, outhouses, vistas and views. Hence, the demands and intensities of preservation and restoration of historical and cultural sites are high and deeply aesthetic along with the approaches being technologically sound.

It is not only enough to restore, rehabilitate or preserve a historical building. It requires to be maintained thereafter. It is the continuous protective care of the fabric, contents and setting of a place that is crucial to the conservation of heritage buildings. Hence, an appropriate and timely maintenance is an important component of any cost-effective conservation programme.

From the perspective of materials science and technology the restoration of historical buildings differs significantly from the repair of modern concrete structures. The ancient construction used lime as a binder, surkhi as a pozzolana, terracotta as a facading material, porous natural stone blocks as the structural elements, and so on as opposed to Portland cement based concrete, mortar and plaster in the modern buildings. The pattern of damage, therefore, is different in the older structures. Repair demands breathable and compatible materials. There can certainly be good opportunities of modernizing the repair materials, without sacrificing their breathability and compatibility. There are requirements of applying modern NDT(Non Destructive Test) and PDT(Partially Destructive Test) facilities to assess structural stability and integrity of the old structures.

Looking at all these technicalities, we felt that this is the time to create some wider awareness amongst the repair professionals about the scope and challenges that are encountered in the sphere of heritage conservation. This is all the more important because vandalism and defilement of heritage aspects are common in our country.

We, therefore, felt the necessity of drawing the attention of our patrons and readers to this large field of heritage conservation in this issue of Newsletter "Rebuild". We have specifically attempted to bring to you some case studies of restoring historical buildings and monuments in this issue.

We earnestly hope that the readers will get some inspiration to delve more into the subject.

We hope you will appreciate the issue.

# Restoration of Historic Massive Masonry

A lecture given by Dr. Casper Groot under Healthy Construction Series organised by Dr.Fixit Institute of structural protection & Rehabilitation at Kolkata & Delhi in June 25 / 26, 2009 on "Restoration of Historic Massive Masonry". The following is the zeast of his lecture based on work done by RILEM Technical Committee. (International Union of Laboratories and Experts in Construction Materials, Systems and Structures.).The main objective of the Technical Committee is to provide Technical guidance for consultants and practitioners through publication of required characteristics of the various types of repair mortars (pending mortar, render and plasters, repainting mortar etc). Since many mistakes are made in practice in choosing repair mortars for historic (pre-existing) masonry which results in damage of the existing historic masonry.

The major repair problems are multiferous types of degradation phenomena which are depicted in figure 1.

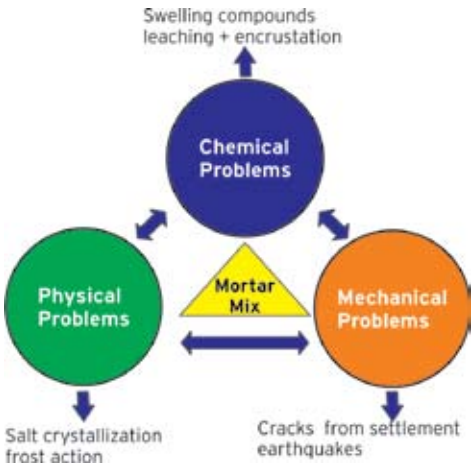



Fig: 1 Degradation phenomena

The damage cases explaining phenomena such as salt damages due to presence of salt in material or from other sources, Moisture in salt solution, it's drying & moves towards drying face, surper-saturation & crystallization / dissolution cycles, lime leaching, mechanical problems such as cracks from settlement, earthquakes etc., physical & chemical problems, and detachment through plant grow & freeze thaw cycling were elaborated. (Figure 1)

Apart from predominant focus on the technical aspects of restoration masonry, other elements such as values, authenticity should also be considered. In order to obtain better insight into influence of different technical factors on the choice of repair materials the analysis of damage cases may be of great help. In fact a keen understanding of the causes of damage is a requisite for taking sound repair measures. A number of damage cases indicated above were highlighted in figures 2 & 3.

Fig: 2 Salt damage of weak pointing material

Fig: 3 Damage through salt Crystallization

From the damage analysis it can be concluded that a lack of compatibility between repair material and the existing fabric is often a premature decay of adjutant's material. In this respect the porosity and moisture transport characteristics are often more important than strength properties. Compatibility and retreatability / repair ability (no negative effects of the current intervention on future interventions e.g. bond between old & new material) are important conceptual as well as practical notions for the choice of repair materials, which in daily practice are often neglected. Compatibility of applied repair material should be such that to protect the adjacent material from premature decay and also be durable taking into considerations physical & chemical behavior between old & new repair material. Some

examples of incompatibility are shown in figures 4 & 5.

Fig: 4 Dense repointing leading to frost damage

Fig: 5 Subflorescence caused by water repellents

The functional requirements for the walls is also elaborated such as to ensure load bearing capacity of the wall, prevent water penetration through wall, resist different kinds of environmental influences and processes acting on wall, to contribute to the aesthetic appearance of a facade & durable performance of the wall. The technical requirements related to surface features, composition (type of binder, aggregate, grain size distribution) strength (compressive, tensile & bond), elasticity, porosity properties, coefficient of thermal / hygienic dilation always with relationship to adjacent materials were also elaborated.

Apart from material characterization the execution of the work is an essential element of the soundness of proposed repair. The repointing practices such as raking (manual & machine) expansion groove, mortar joint section repointing etc. has been highlighted in figures 6 and 7.For this a clear rectangular space instead of a V-shaped joint must be raked in the mortar joint of width not less than twice the joint thickness for placing the repointing mortar.

The prevention of moisture ingress, influence of water repellent to drying was also delt upon.

Fig: 6 Raking out of joints mechanically

Fig: 7 Repointing

The prevention of moisture ingress, influence of water repellent to drying was also delt upon. Some examples of mineral grout, polymer injection, anti staining coating and techniques used for this were also discussed.

India has a large number of historic masonry structures which are not only beautiful, but also integral part of socio-political history of pre-independent era. Restoration of those beautiful architectural marvels with the present generation materials are of great challenge and can be effectively addressed to maintain their aesthetic, dignity and heritage.

The full paper of Dr. Casper Groot on “Choosing Repair Mortars for Historic Masonry : a case study” can be refered in our forthcoming International Journal of 3R’s (Repair, Restoration and Renewal of Built Environment)

# Structural Preservation of Monument

**A Case Study Of Lord Jagannath Temple at Puri, Orissa**

By N.C. Pal

(Excerpt of proceedings of All India Seminar in Rehabilitation of Structures by Institution of Engineers, Bhubaneswar in 2003 from pages 8 to 22.)

## Historical Background of Jagannath Temple

Lord Jagannath temple at Puri (Figure 1) was constructed in the first quarter of the 12th century. The monument is standing on a high platform connected with the ground level by flight of 22 steps (belived to be part of it's foundation). The height of temple is over 66 mt. It is only 2 Km away from the sea.

Fig: 1 View of temple complex

## Structural Problems of The Main Temple and Need for Intervention

The construction of Lord Jagannath Temple has been done in ashlar stone masonry with blocks of Khandolite (a local sand stone) laid in courses. For the construction, no mortar has been used. Instead the stones have been jointed with help of wrought iron U-shaped cramps or dowels and have been supported one over another resulting fascinating wall and corbelled roof, in the shape of frustum of pyramid. The geometrical arrangements of the stones perfectly match with the proven thesis of arches, where all the elements are primarily subjected to compressive forces. The wall thickness of the main temple is about 5.5 metre and the main temple has three floors, i.e. three corbelled roofs inside, which are being supported by huge wrought iron beams (about 25 cm. x 25 cm. solid section), spanning over 9 metre of length. The wall face externally has been plastered with 45 cm. thick coat of lime plaster, applied in nine distinct layers, while the inside wall has a thin coat of plaster up to a height of 3 metre.

The maximum damage to the temple was caused by the rusting of these clamps. Apart from this the stone expanded due to seepage, generating pressure and causing chunks to fall.

The outer faces which was covered with lime plaster (about 45cm) had failed to control saline induced deterioration and leakage besides putting extra pressure on the fabric of the temple and hiding the beautiful carvings.

It was found that the condition of the inner walls and corbels required attention. Similarly, on the southern side of the temple major structural weakness were detected in the form of multiple cracks, missing architectural pieces, etc.

## Intervention Schemes

The following recommendations were made by the expert committee which was subsequently implemented through a joint venture of engineers from ASI and the State PWD (Public Works Department).

I. Replacement of missing corbels as per the original.

II. Replacement of rusted wrought iron cramps by stainless steel cramps.

III. Sealing of the stone joints by a joint sealant comprising stone dust, cement, polymer (acrylic type) and non-shrink additives.

IV. Grouting the inner core with polymer modified, flexible, non-shrink, cement grouts.

V. Anchoring the loose cantilevers and corbel stones with help of 1.5m to 2.5m long, threaded stainless steel anchors, grouted with low viscous epoxy resins.

VI. Providing a stainless steel anchors, grouted with low viscous epoxy resins.

VII. Providing a stainless steel space frame, as a secondary defence to support the ground floor corbelled roof.

VIII. Lateral confinement of the entrance corner walls of each floor by stainless steel flats.

IX. Improvement to the existing ventilation system by drilling appropriate diameter holes through the ceiling of the first and second floor and provision of suitable ventilation duct in the top floor.

X. Provision of temporary support to the ceiling of the first and second floor in the form of tubular scaffolding system to monitor corbel movements and any associated deformation in those floors.

XI. Desalination of the external fascia stones by paper pulp technique.

XII. Application of suitable chemical preservative to the fascia stones (in place of methyl metha acrylate) and suitable biocide treatments.

## Consolidation Of Temple Wall And Corbels

The walls and corbels of the main temple had shown gross deformations with weakening of interconnections of structural elements, thereby endangering the very stability of these structures. This is primarily due to the ingress of rain water through the weathered joints into the thick dry stone walls thereby leading to the rusting of iron dowels / cramps. It has been proved with success that injection of polymeric grout into the pore structure of the masonry diminish the splitting forces and at the same time increases the adhesion between the stones. Therefore, for structural stability and proper load distribution of the space frame and to prevent the water ingress into the core of the structure, it was felt necessary to take adequate conservation measures by sealing the joints, surface cracks and grouting the walls with a material which besides meeting the general requirement, would also be compatible with the structural behaviour of the Ashlar masonry structures. Considering the condition of the temple structure, its structural design and inherent weakness, results of the analytical study regarding the stability of the temple against the earth quake forces and requirement for uniform load distribution from proposed stainless steel space frame, it was essential that the injection grouts should meet the following main criteria :

1. should not be excessively brittle
2. should be elastic having resilience and permit minor movements without fracturing or cracking
3. should firmly adhere to the stone surface
4. should be able to set without curing, without any deformation.

The first three characteristics are also essential for any mortar mix used for sealing of open joints or cracks and the last characteristic being of additional advantage. Since the ordinary Portland cement mortars suffer from shrinkage cracks and are excessively stiffer and strong, their use for sealing of joint as grout material appears to have certain limitations. For historical buildings, the grout materials should be compatible with the structural behaviour and for this purpose, the properties of cement mortars need to be modified for the present ashlar masonary structures.

Typical test samples were prepared from the same ordinary Portland cement with polymer loadings of 5% and 10%. The materials used for the different grout mix formulations are :

1. Ordinary Portland cement
2. Modified Acrylic Resin Emulsion of Methyl Methacrylate with copolymer of 2-ethyl hexa acrylate and butyl acrylate. It has 40% of solid resin content.
3. A solid component material of expanding and plasticizing nature to help in low water / cement ratio, positive expansion for non shrink infilling and jointing.
4. Admixtures based on selected lingosulphonates which is adsorbed on to the cement particles and acts as a dispersing agent and breaks down agglomerates of cement particles and enables the water in the mix to perform more efficiently.

To evaluate the effect of polymer loadings in different proportion and other additives on the setting time and mechanical properties of Polymer Modified Cement (PMC) mortars, the following formulations were used in the experimental study. In all the tests, cement sand were added in the ratio of 1:3 by weight.

I. Cement

II. Cement : Polymer :: 4:0.5

III. Cement : Polymer :: 4:1

IV. Cement : Polymer : Expanding grout additive : 4:1:0.02

V. Cement : Polymer : Expanding grout additive : Plasticiser Cum Retarder :: 4:1:0.02:0.02

Since the polymer emulsion has 40 percent solid content, the polymer added in the above formulations II & III corresponds to 5 percent and 10 percent loadings respectively. Experimental studies for setting time, compressive strength, flexural strength and bond strength were carried out for the above mix formulations and it was observed that polymer loadings with addition of plasticizers and retarders help to secure adequate adhesion with the stone surface. The elastic behaviour of PMC grout will induce the required flexibility in to the system. Results of polymer loading in different proportions along with other additives on the strength characteristics of PMC grouts were thus experimentally verified and applied accordingly. Additional temporary stresses generated by forces or constrains on masonry, produced during the grouting process were controlled by selection of proper grouting parameters.

## Seismic Safety Assessment of the Temple

The temple falls in seismic zone III according to the available quantitative seismicity maps. Instances of occurrence of earthquakes of magnitude around 5 on Richter scale have been recorded at about 100 to 150 kms South-east of Puri. The analytical study has been carried out by the Civil Engineering Department of Indian Institute of Technology, Kharagpur to check the stability of the block structure of the main temple against earth quake forces. The results of the analysis indicate that the temple structure will safely withstand forces developed due to seismic excitation up to a Richter scale of 5.0. Since the loosely joined stone blocks as in case of massive structures built in ashlar masonry are less vulnerable to earthquake induced vibrations than the solid structures, it was essential to see that the grout materials using injection techniques will not solidify the structure fully and alter its structural behaviour completely. For this purpose, the use of PMC grouts was considered favourable.

## Treatment of The Distress Outer Fascia

The outer and inner fascia of the temple core are made from Khandalite stones. Khondalite rocks being of metamorphic sedimentary origin, with evidence of post magnetic action, are essentially heterogeneous with several types of inclusions. Subjected to the exposure of salt laden air, moisture, air borne sand particles etc. both in isolating and combination, the surface of the temple structure and the sculptural features have shown extensive distress. The anxiety was two fold: structural strength and damage to scriptural features. There was evidence or large scale leaching from the surface layer and ingress of moistures of deep inside the walls, not only along the un-mortared joints but also within the main (individual) rock bodies. The process has been further accelerated due to high humidity and temperature. This had significantly increased the porosity of the stones, thereby hastening the process of deterioration. Evidently, the formation of the water soluble salts has taken place. These soluble salts had subsequently leached out from the interior of the stone structures enhancing their porosity several folds. All this appears to explain a typical poker faced features on the surface of the stone. Evidently there is loss of strength of the rocks progressively with aging. As the stone of the choice (khandolite) is not very homogeneous, samples collected from different locations exhibited different stages of distress. It is highly relevant and appropriate to emphasize here that this non-uniformity demanded difference in treatment mode for different stones even when the basic chemical system was the same. Moreover it should also be recognized that this process of progressive deterioration got accelerated with time.

The objectives of the chemical treatment to the outer surface was therefore planned such that :

- Tubular scaffolding were made for treatment of outer faces as shown in (Figure 2).

Fig: 2 Renovation of outer face

- The treatment should be compatible with the basic stone in respect to chemical bond as also thermal expansion / contraction and moisture movement.
- The sealant or consolidant should not develop a tight and impervious surface skin preventing access of moisture. This tends to develop pressure behind the treatment causing other kinds of damage caused by trapped moisture drawn to the surface by temperature gradient. The sealant should discourage ingress of fluid but encourage transmission of vapour.
- A merely physically coexistent system should fail to be durable and act as consolidant.
- Silicones, urethanes, acrylates have been tried for limited sealing of sandstone surfaces but the efficacy depends on the fluid vehicle, the emulsifier and the molecular size of the sealant.
- Equally important are the characteristics of wettability and response to UV radiation.
- The treatment should permit trapped salt to escape.
- The fluid vehicle should be water or water miscible.

It may be noted that various organic or organo-inorganic polymers and polymeric precursors, which are finding increasing use as consolidants are alkoxy / saline silicates, epoxy resins, microcrystalline waxes, poly acrylate / methacrylates, silicone resins, polyurethanes. Still there is a need to find tailored materials for better end results. In order to search out a chemical system that would be compatible with the eroded and degraded

khondalite stones a set of test parameters were identified to compare response of treated rock samples with that of untreated samples.

- Chemical uptake to stabilize a surface zone, upto a depth not less that 5-10mm depending on the state of deterioration was measured.
- Capailary absorption studies to indicate susceptibility of water penetration were carried out.
- Electron microscopy to study the surface morphology and texture of the treated samples was carried out.
- Porosimetric studies to measure pore size distribution profile of polymer treated sample were carried out.

The treatment to the kalash shown in (Figure 3) and temple after complete renovation shown in (Figure 4).

Fig 3: Treatment being given at kalash

Fig 4: Temple after renovation

## Conclusions

In case of historical buildings and monuments made of masonry, it is important to have sound assessment and diagnosis of structural behaviour prior to any permanent intervention. It is also impossible to predict the behaviour prior to any permanent intervention. Since masonary is a non-elastic, anisotropic and non-homogeneous material, it is generally impossible to predict the behaviour of masonary buildings from the mechanical properties of the constituent materials as the input parameters in the calculation procedures which are based on the assumptions of the theory of elasticity. It is especially so in case of ashlar masonry buildings having thick dry stone walls where the core has relatively loose prior to any permanent intervention. Since masonary is a non-elastic, anisotropic and non-homogeneous material, it is generally impossible to predict the behavior of masonry buildings from the mechanical properties of the constituent materials. It is especially so in case of ashlar masonary buildings having thick dry stone walls where the core has relatively loose stone blocks and the outer veneering structural members are held together by iron cramps / dowels. These dowels in due course of time have rusted into powder forms leaving voids in between stone blocks where they once were. These type of structural problems are mainly tackled by structural consolidation with help of grouting as was done for the Puri temple. When dealing with the repair by grouting of masonry structures, the improvement of their carrying capacity has certainly to be considered as one of the most important aims of the intervention. Nevertheless the long term performance and durability of repairs has also to be taken into account; repairing should also ensure an increase of the service life of the structure. The effectiveness of the grout from the point of view of bond strength, improvement of the mechanical strength of decayed masonry and durability of injected grout to thermal cycles should be experimentally verified before application. The main problem associated with grouting is determination of pressure distribution as well as the analysis of stress applied to the mass of masonry during injection. These are in general difficult to be solved theoretically. The difficulty stands on the inability of geometrical presentation of voids system, the particularity of the system of voids itself, as a flow duct, the great variability of flow conditions and further more on the number of parameters involved (kind and composition of grout, kind and geometry of masonry etc.). The control of applied stress is made through practical limit state checks in accordance with the type and geometry of masonry in the point of pressure application. In case of Puri temple restoration work, two checks namely, check of blowing stones out of the masonry face and check of horizontal swelling of masonry were made to control the grouting process.

Period of repair : 1992-1993

Owner : Sri Jagannath Temple Administration, Puri

Repaired by : Archeological Survey of India and PWD Govt. of Orissa

Expert Committee: ASI, PWD, SERC, CBRI, IITK, RRL Bhubaneshwar

# The Importance of Moisture Protection in Preservation and Restoration

By John F. Maillard CSI-CDT

(Extracted from Applicator Magazine, vol.28/No.4,2006, pages 19-20, published by SWRI)

Water has destroyed or damaged more structures than wars and natural disasters! Unfortunately, moisture protection often takes the back seat in most restoration projects. Our landmark architects, engineers and conservators have an enormous challenge. They are required to preserve or restore historic structures while meeting new seismic and local codes; new uses that the structures were not originally designed for and limited budgets.

## The moisture protection challenges

1. They are practically all non-drainable wall systems. They depend entirely on the exterior surfaces for the barrier preventing the water intrusion. This is not realistic in an imperfect world. Every joint and transition should be perfectly watertight, which requires perfection in installation and materials.

2. Most of the exterior components are very porous (mortars, bricks, stucco, sandstones, marbles and woods). Such substrates absorb moisture that eventually damage or destroy these components. The result is not only interior water damage but also biological growth and mildew.

3. The mortar joints are mostly responsible for preventing the water intrusion. They do not last forever. The repointing procedures are very costly and therefore often omitted or partially performed, and frequently with non-compatible mortars.

4. Our forefathers had a tendency to marry materials that do not want to be married. They joined masonry with wood without adequate transition joints. The mortar joints between these totally different substrates created problems instead of solving them. They were also stingy with the flashings to divert the water away from the masonry units.

## Addressing these challenges

1. **The non-drainable wall systems** - Whenever possible, adopt one or two principles of moisture protection: barrier – drainage – diversion. This can be accomplished by installing pan flashing under the windowsill tracks, head flashings, and cap flashings, drip edges to divert the water. Naturally, providing and maintaining sound mortar joints are still the most important barriers.

2. **Porous substrates -** This is a very controversial subject. With the exception of marble and limestone, it is impossible to reduce the porosity by honing and to that end; several conservators are reluctant to specify clear water repellents. This subject is battled for over 40 years by the author and today; it is convinced that the reduction of porosity is necessary and that the clear water repellents such as silanes and siloxanes are a valid solution to this problem.

Following are typical examples of the need for porosity reduction being executed by the author as a contractor.

The Sharon House, Golden Gate Park in San Francisco: The sandstone was cleaned, repaired and 100 percent repointed, then a siloxane was applied. Thirteen years later the building is in pristine condition.

The statue in Spreckels Hall of Music, Golden Gate Park in San Francisco was restored the same year 1992. However, the same client omitted the application of a clear water repellent on the repaired and restored sandstone. Thirteen years later, the fungus and biological growth are back with a vengeance. Every winter it would turn green and every spring it would be cleaned with a standard restoration cleaner.

Finally, It was decided to perform a little test. After cleaning the statue in April of that year, a Silane clear water repellent was applied on one side while covering the other side with a visqueen. The following spring the difference was obvious. The treated half did not have a single trace of mildew.

Hence these examples demonstrate the importance to reduce the porosity of the substrates. We should consider that the clear water repellents are not a barrier or waterproofing solution but instead are a way to reduce the porosity of the substrates when honing is not an option. Depending on the materials, the average water repellency capacity is four to five years. Fortunately re-application is relatively inexpensive compared with re-cleaning.

3. **Mortar joints**- Use of different pointing methods and materials including parging is very much suitable for preventing water intrusion. One such example is Chapel of St.John of Jerusalem in Fribourg Switzerland built in 1512 and kept well pointed all these years and is in remarkable condition today.

4. **Marriage of incompatible materials -** Proper flashing and installing a proper transition joint between the different materials with a suitable sealant will solve this problem.

# Masonry Repair and Moisture Protection

**A Case study of Russian Church of the Holy Trinity, East New York**

By Kevin Yuers

(Extracted from Concrete Repair Bulletin, January/February-2005, pages 22-24, published by ICRI)

Trinity was built in 1935 and located in the East New York section of Brooklyn (Figure 1).

Fig 1: Church of Holy Trinity

Constructed in a traditional Byzantine style, the masonry structure features large, onion-shaped domes, semi-circular arches, and high arched windows. It features two distinctive domes, the smaller of which functions as a three-story bell tower and houses three massive church bells. At the top of the bell tower, four louvers–one on each of the four sides–enable sound to travel out of the tower.

## Distress observed

By the summer of 2003, the 68-year-old church was showing its age. Years of weather, soot, and air pollution had taken their toll. The church's exterior, particularly the front steps and massive front columns, were soiled with years of dirt and buildup.

Fig 2: Distress in plastering

Much more of a concern than the cosmetic problems, however, was the fact that the mortar in the brick exterior was beginning to erode and water had begun leaking into the bell tower and the south-east chimney. Water had also begun entering the bell tower's louvers during heavy rains.

Water that made its way into the bell tower would pool on the third level's concrete floor and then seep through to the second level and into the choir area of the church below. The plaster on the ceilings and walls of the church was being destroyed (Figures 2 & 3) by the water damage. But most distressing was the fact that the many historic religious paintings were being damaged and destroyed (Figure 4).

Fig 3: Distress in internal walls

Fig 4: Damages in wall paintings

## Planning of Repair

In the summer of 2003, the church decided to repair and upgrade the structure to address the immediate leakage problems and avoid further damage to the structure and its contents. The upgrade involved a general cleaning of the front entryway, cleaning and sealing the exterior of the bell tower and southeast chimney, repairing the brick in those areas, and protecting the chimney and inside of the bell tower against further leakage.

## Repair Methodology

The first step in the process was to remove 68 years of urban grime from the outside of the bell tower and the southeast chimney. A local contractor was hired to power wash all the brick work in these areas using a high-pressure compressor. Then, the original, eroding mortar was removed from around the brick and replaced with new standard brick mortar grout.

Once the brick had been repointed, two coats of a fast-drying water repellent sealer were applied with a sprayer to the exterior vertical surfaces. The church elected to use a sealer containing a blend of silane and siloxane compounds designed specifically for brick, masonry, and concrete that reacts with silicates below the surface of the brick to form an insoluble, water-repellent barrier. Because the finished application is invisible, the original appearance and breathability of the brick are maintained. The sealer is designed to not fade, yellow, crack, peel, or wear away.

When the exterior work was done, the church's interior leakage problems were addressed. On the third (top) level of the bell tower, where a sloped concrete floor had recently been created to direct any incoming water to an external drain, a local contractor applied a cementitious crystalline water-proofing product to fortify the concrete and stop water from leaking through to the second level of the tower.

Fig 5: Cementitious crystalline waterproofing on external surfaces

The crystalline waterproofing product reacts with concrete to form crystals that migrate into the concrete to block pores, voids, and tiny cracks that would allow water penetration. Over the life of the structure, these crystals will continue to react with incoming water to self-seal small cracks, providing long-lasting protection against leakage. For extra reassurance, the church opted for a product with a 10-year guarantee.

A similar sloping concrete slab was constructed on the second level of the bell tower to direct water to another external drain. This time, a crystalline concrete waterproofing admixture was incorporated right into the concrete slab, providing another layer of protection against leakage.

For the southeast corner chimney, the contractors created a new concrete cap top, which also incorporated a crystalline concrete waterproofing admixture. The entire chimney was then power washed, repointed, and spray-coated with two layers of water-repellent.

To finish off the repair and renovation project, the church then hired local contractors to clean the structure's front steps and massive columns. While it took some experimentation to find a solution that would remove nearly 70 years of city dirt and grime, eventually a specialized brick and concrete cleaning product was located that enabled the team to clean the columns and stairs and restore them to their original luster.

To minimize inconvenience to the church's congregation, repairs were completed between Monday and Friday over a period of 1-1/2 months. The project was completed in the fall of 2003.

Results of the renovation have been highly successful. Outside, the church entryway looks new. More importantly, though, the repair and water-proofing efforts in the bell tower and southeast corner chimney have proven to be highly effective. Despite a number of heavy soaking rains in the 9 months since the project was complete, no further water infiltration or damage has been detected.

Pleased with the results of the initial repair project, the church is now considering undertaking similar work in the rest of the structure as a preventative measure. Satisfied that the leakage problems have been solved, the church has begun selecting artists to commence repairs on the plaster and religious paintings and depictions inside the church.

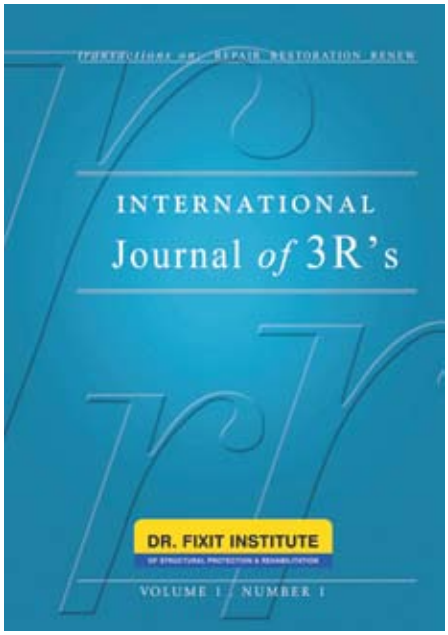
Owner: Russian Orthodox Church of the Holy Trinity,Brooklyn, NY

Repair Contractor/Supplier : The Crystol Group.Huntington Station, New York

Material Suppliers:Crystol Concrete Products Goldens Bridge, New York & Kryton International, Inc.,Vancouver, British Columbia, Canada

## International Journal of 3R's (Repair, Restoration and Renewal of Built Environment)

Dr. Fixit Institute of Structural Protection & Rehabilitation (DFI- SPR) as a part of information dissemination effort in the field of Repair, Restoration & Renewal Engineering is on the verge of introducing a new techno-scientific Journal (3R's) of International status and quality.




**Journal Scope:** To promote and coordinate developments and practices for enhancing the service life of Built Environment.

**Unique Feature:** A multidisciplinary journal with a broad based readership of researchers and practitioners worldwide with backgrounds in Civil, Chemical and Mechanical Engineering on one hand and Materials Science and Chemistry on the other.

### Call for Papers

The journal is proposed to be a refereed journal, publishing only articles of the highest quality that are original, cutting-edge, well-researched and of significance to the international community at large and the national and regional professional segments in particular. The journal will also publish original review papers and researched case studies of international significance. The primary gaps to be filled are those between researchers and practitioners in the field of 3R's. The endeavour will be to bring in a broad blend of scientific, technical and practical papers.

The proposed journal will be devoted primarily to recent advances and innovations in materials, systems, technologies, equipment and engineering of repair, renewal and restoration of both infra- and superstructures. This will cover variety of structures such as buildings, bridges, underground and underwater structures in diverse environmental conditions.

Papers should be submitted through email to *editor3r@pidilite.co.in* and *info@drfixitinstitute.com.* However, in unusual circumstances authors may submit papers in duplicate hard copies along with a soft version.

Queries about submissions from potential authors should be addressed to the Editor-in-Chief at *editor3r@pidilite.co.in.*

**Last date for Submission of Paper for the 2nd issue : 30th November, 2009**

For author's guidelines and submission of paper please visit our websit http://www.drfixitinstitute.com

**Editor-in-Chief**

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**Forthcoming International Events**

## HMC 2010 : "2nd Historic Mortars Conference" & "RILEM TC 203-RHM Repair Mortars for Historic Masonry" Final Workshop

Prague, 22-24 September 2010

**Conference Objectives**

To bring together scientist, technicians and professionals involved in research and studies of historic moratars to present and discuss advances in conservation of historic buildings. This is a unifying field where a truely interdisciplinary collaboration and contributions are needed from archaelogists, architects, civil and structural engineers, geologists, material scientists, chemists, coservation scientists and art restorers interested in mortar. Special focus of the conference will be on application research and technical knowlegde to conservation practice and vice versa in its reflection on such recommendations.

**Conference Themes**

Characterisation of historic mortars, assessment of mortars and masonry, Conservation and restoration issues & Repair mortars for historic masonry

**Preliminary Registration**

Interested participants are kindly asked to preliminary register by email or via website in order to receive future conference information and announcements.

**Contact**

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website : http://www.itam.cas.cz/HM2010

# The Institute's Activities

## Training Programmes

Organised Training Programme on "Buildings -Waterproofing, General Repairs and Maintenance of Concrete Structures" for Public Works Department (PWD ) Engineers, at Konkan Bhavan, C.B.D. Belapur Navi Mumbai, on 8th Sept 2009.

Organised Training Programme on "Waterproofing of Critical Building Areas " at Ispat Industries Limited, Dolvi plant, Wadkal Naka, Pen, Raigad, for their engineers on 10th July 2009.

## Technical Seminars (Healthy Construction Lecture Series)

DFI-SPR has organized technical seminars under "Healthy Construction Lecture Series" on 20th Aug 2009 in Ahmedabad. Dr. Sudhir K. Jain, an eminent personality in the field of Earthquake Engineering and Director from IIT Gandhinagar has been invited as the Guest Speaker to deliver a special lecture on "Seismic Assessment & Retrofitting of RC Frame Buildings". The programmes was acclaimed by the prominent delegates from the engineering fraternity of the city.


# Training Programmes and Courses



DFI– SPR has scheduled a list of training programmes for the year 2009 - 10. These programmes have been designed for upgradation of knowledge base of practicing engineers in the field.

## Training programmes for Nov 09, Jan & Feb-10

| Sr. No. | Month | Date | Topic | Fees | Details of the topic |
|---|---|---|---|---|---|
| 1 | November-09 | 19th and 20th November | Structural Diagnosis and Condition Analysis of RC Structures | Rs. 3000/- | • Distresses in concrete structures<br>• Condition survey<br>• Diagnostic techniques<br>• Methods of non destructive tests<br>• Damage rating<br>• Repair techniques |
| 2 | January-10 | 14th and 15th January | Building Maintenance - Waterproofing and General Repair | Rs. 3000/- | • Leakage, cracking and manifestation of other distresses in concrete structures<br>• Building Envelope<br>• Advanced waterproofing materials, systems and application methodologies<br>• Periodic health check and diagnosis of damaged structures<br>• Crack and crack repair materials<br>• Maintenance schedules and strategies |
| 3 | February - 10 | 26th February | Corrosion and Protective Coatings | Rs. 1500/- | • Environmental distresses of concrete structures<br>• Assessment of corrosion in RC structures<br>• Methods of corrosion protection for reinforcements<br>• Protective coatings for concrete |

## Distance Education Correspondences Courses jointly with NICMAR

Six month Graduate Certificate Programmes are being organized by DFI-SPR, with NICMAR for Practicing Engineers in following subjects:

1. **Waterproofing and Maintenance of Concrete Structures**
2. **Advanced Technology for Concrete Repair**
3. **Application of Polymeric Materials in Construction**

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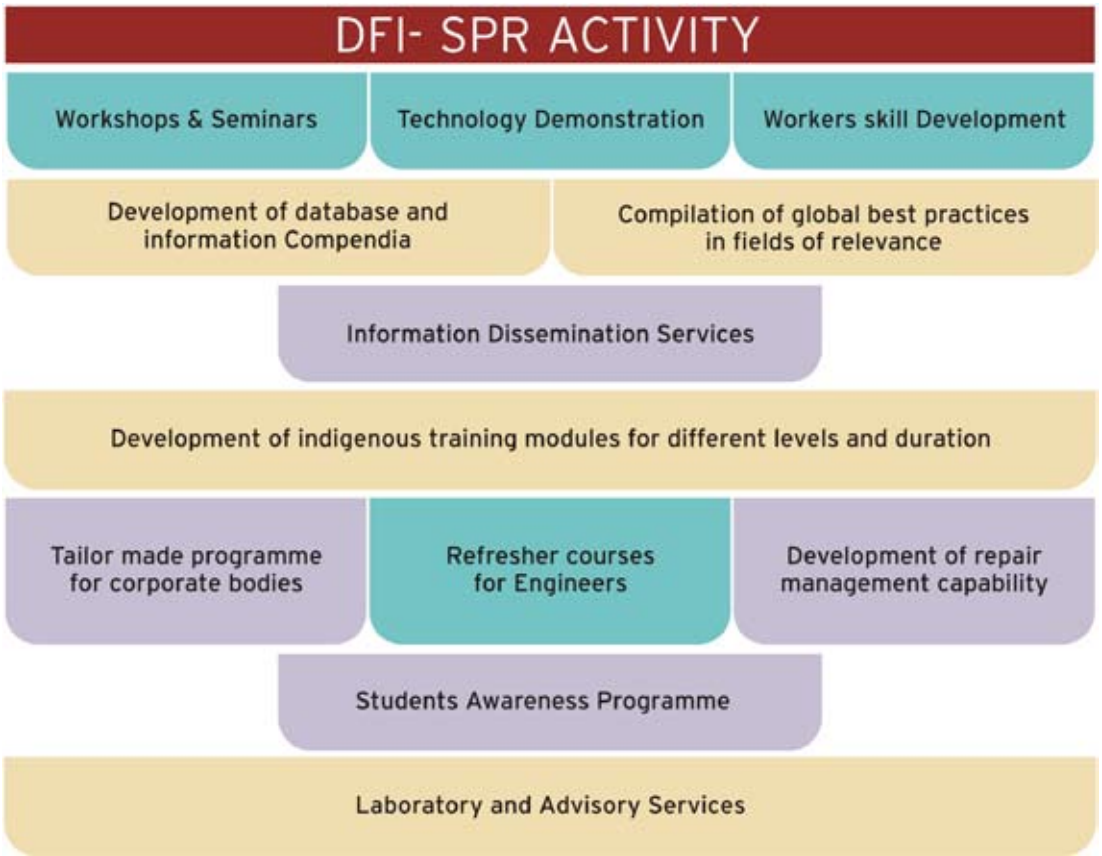
## VISION

To become a premier national knowledge and skill development center in waterproofing and other areas of renewal engineering through international networking in order to proliferate the global best practices in the country.

## MISSION

To act as a platform for enhancing the service life of built environment through global sharing of knowledge and practices in the field of waterproofing, structural protection, repairs and rehabilitation.

### DFI - SPR : ACTIVITY CHART

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## Reader's Feedback & Interaction Solicited

(For feedback kindly use our postpaid reply card placed inside)

Our Newsletter is focused on good concreting practices, waterproofing, repair, rehabilitation and maintenance of concrete structures and buildings. Any reader, who wishes to contribute his or her experience or achievements in this field to our Newsletter for wider dissemination, may send the details to:


**The Editor-'Rebuild'**
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