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Uniformity Formulation in Structural Audit Reporting of RCC Building (Civil Domain Part 1)

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Abstract: ***The future of the structure whether to be rehabilitated/repair or demolished is dependent on the conclusion of the Audit report. Standard system must be devised that will serve as a protocol for assessing the degree of deterioration of the structure. This standard system must include uniformity which will be followed by all the Structural auditors, so that the conflict of opinion must not transpire. The objective of uniformity formulation is to design rating system which is objective. The subjective analysis should be kept as minimum as possible. This paper reviews first part in which different research papers have been accessed, defining the different types of distress, characteristics of material in civil domain (Wall, Plaster, Water Leakage, Plumbing) which would be incorporated in the 2nd part. All the findings reported in this field are presented and further research opportunities and challenges are also discussed in this review.***

Keywords: Structural audits, Cracks, Blistering, Efflorescence, Joints, Relative Humidity, Modulus of elasticity, Shrinkage, Porosity, Toughness, Loads, Rehabilitation, Crack resistance, Capillarity, Strain rate, Tension, Durability, Seepage, Uniformity

1.Introduction

Structural Audit of a building means everything connected to the conduct of a building, which includes strength of the columns, beams, pillars, iron bars, plasters, walls, sewage discharge systems, water pipeline systems, etc. The need of structural audit is for maintenance and repairs of existing structures timely which leads to prolonged life of the building and safety of the occupants to avoid any mishaps and save valuable human life. The periodical structural auditing of existing buildings is thus of utmost importance in finding the present serviceability and structural viability of structure. [Ref no.15]

- To understand the condition and health of the structure
- To check actual reliability of the structure.
- To highlight the critical areas of the structure that needs immediate attention.
- To abide by the Municipal or any statutory requirements.

The guideline for doing audit is not properly defined. Different qualified structural auditors /engineers differ in view with the degree of distress for same structure at given point of time. As the procedure is vaguely defined audit reports differs vastly.

The objective for taking this topic is bringing uniformity in Structural Audit. With this there will be no conflict between audit reports of different Structural Engineers. It will allow us to reach to the conclusion expeditiously as well as efficiently. For doing this first we must study all the distress endured and characteristics of the materials utilized for it.

In this paper the main focus has been put to study defect and the characteristics of materials on shell of the structure which are categorized as follows:

- Plaster
- Wall
- Water Leakage
- Plumbing

This section should be succinct, with no subheadings.

2.Materials and Methods

1. Plaster

- **Permeability**

Relative humidity has an important impact on water vapor resistance factor. The border conditions can have the significant impact on the water vapour resistance factor but also the standard according to a sample is tested and evaluated, because each standard requires different testing conditions. Besides, the value of water vapour resistance factor is influenced by: an inaccuracy of the determination of particular quantities; an inaccuracy of the measuring; changes of surroundings (temperature, humidity, pressure); other impacts (a sample manufacture technology, duration of achieving of a steady state); errors of a reading and an incorporation of data into the calculation. [Ref no.1]

- **Cracking**

As modulus of elasticity and shrinkage deformation in plaster increases the probability of plaster cracks increases. If high strength mortar is used then the probability of cracks in plasters increases. The plaster layer attachment to the wall plays an important role for its reliability. If there is displacement between Plaster layer and backing is assumed then their length plays an important role. The Dependence stress displacement is the main characteristic for cracking in plaster and its bonding. To reduce the likelihood of normal cracking, lower the elasticity modulus and shrinkage deformation. [Ref no.2]

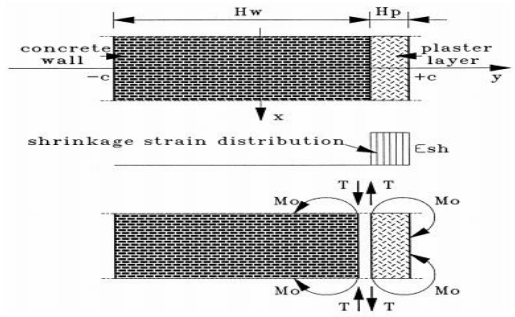


Fig. 1. Concrete wall covered by plaster layer: geometry (at the top); shrinkage strain distribution (in the middle) and internal forces in the 'slitted' member (at the bottom).

The plaster toughness is size dependent and has proposed a thermodynamic approach to its fracture. Dry plaster is characterized by a linear elastic macroscopic behavior and it has been reported that its hardness and elastic modulus decrease with increasing porosity. . Interaction of the main crack with secondary ones undergoes substantial branching and crack accelerations leading to bridging destruction due to sudden crack opening. The material microstructure, especially the presence of large pores, and the low bond energy between crystals, allow nucleation and propagation of secondary cracks even far away from the main crack tip. [Ref no.5]

- **Sustainability**

The increase of residues in mortars compositions led to the rise of equivalent air layer thickness, for both type of sand and ceramic residues. The rise of the percentage of ceramic fragments increases open porosity and reduces drying capacity and water vapor permeability. The higher amounts of smaller ceramic particles of the red ceramic residues also prompt some changes in physical behavior of these mortars. [Ref no.3] If ceramic residues in the proportion of mortar are less then the dry capacity of mortar increases which in turn cause cracking of plasters. Decrease in percentage of ceramic fragment increases porosity, reduces drying capacity and water vapor permeability. The size distribution of the aggregates reveals a major influence in mortars behavior. The type of river sand used may have caused changes in mortars porosities, directly affecting strength and elasticity modulus.

- **Gypsum Drying cycles**

The use of gypsum is limited in wet areas and places where there is a possibility of contact with water and outdoor conditions. The strength of moistened gypsum decreases by 1/ 3 compared to dry material and the surface loses its natural hardness. If the plaster element is continuously subjected to water-saturated conditions then the mechanical strength decreases. This weak condition lasts longer as thick elements take a longer time to dry. The amount of inter connected pores and the water absorption rate of the material increase. There is a very strong relation between the porosity and the water absorption of gypsum plaster. Similar to the porosity results, it was found that the increase in GBP and fiber content increased water absorption.

2. Wall

- **Behavior of Brick Lintel**

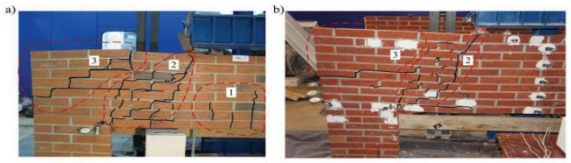


Fig. 8. A general view of lintel failure: (a) lintels SR1, (b) SR2.

When brick masonry is constructed without lintel beams, it causes failure of wall in its lifespan. Crack on walls mainly occurs due to Bending Moment, Ultimate load and post ultimate load. Wall cracks are mainly observed in Diagonal Cross Section. All in all the bearing capacity of the wall increases with the provision of the lintels. Fixing bricks in the bottom row of the lintel by special joints hanging them next to the longitudinal reinforcement of bed joints is a reliable procedure. [Ref no.6]

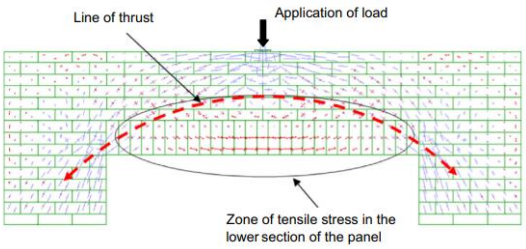


Fig. 10. Distribution of the principal stresses just before the occurrence of the first crack.

The application of the external vertical load at mid span of the wall panel induces high compressive stresses at the corners of the opening and horizontal tensile stresses at the top of the soffit of the panel. The tensile, friction and cohesive strength is not proportional to the ultimate load that the wall panel can carry.

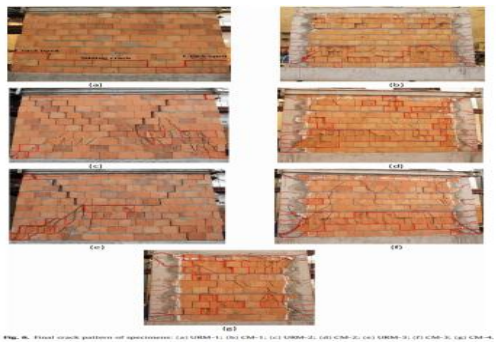
1. The influence of the friction and cohesive strength on the ultimate load that the panel can carry is significant.
2. The influence of the interface friction and cohesive strength on the ultimate load are also significant but less than that of the tensile strength. [Ref no.9]

- **Wall frame Connection**

The study revealed that zigzag connection and short anchor did not improve the performance of the confined masonry wall; instead it is more likely to reduce the performance of the wall. Crack patterns and failures on the brick wall were initiated by vertical crack on the face of wall-frame connections, which then reduced the confinement of the wall.

Conversely, continuous anchorage strengthened the confinement of the wall and allowed the development of diagonal crack patterns. As a result, the strut and tie mechanism between the wall and the confining column was able to develop as lateral load resistance mechanism. [Ref no.7]

- **Wall cracks**



Higher axial load ratio caused much more brittle destruction, and lower one would induce obvious shear sliding. Even though these positive factors could enhance the behavior and change the failure mechanism, the masonry brittle destruction failure was still the significant feature. The increased axial load would induce severe brittle destruction, resulting in crushed webs and shells for shear effect, as well as a relatively rapid loss of strength. A higher axial load ratio resulted in significantly more brittle degradation, while a lower one resulted in evident shear sliding in the wall. [Ref no.8].

Wall cracks may also be inducing due to inadequate foundation capacity. This capacity reduction is due to the improper calculation of saturation of the soil. Different settlements result in structural movement, which can put an excessive amount of stress on masonry walls. The inadequate foundation capacity potentially causes the different settlement that generates structure movement and affects the masonry wall stability. [Ref no.12]

- **Shear Moment effect**

When moment reaction is induced in the wall, the shear strength capacity of the wall decreases. Cracking is also evident in the hysteresis curve, or in the lateral load history, because it induces a sudden decrease in strength before the target displacement of the cycle is reached. The shear strength of a wall is reduced whenever a flexural moment is applied on top of the wall in such a manner that it bends with simple curvature. The effect of the moment on the shear strength is more important for slender walls and increases with the elastic moduli ratio G=E. The peak shear strength also decreases with the application of a moment on top of the wall; however, the reduction is less than the reduction at the onset of cracking. A formal approach or heuristic to predict the peak strength reduction due to the shear-moment interaction is not yet available. These results suggest that nonlinear lateral displacements due to flexural cracking are unrelated to the shear strength because they did not affect the prediction based on linear elastic behaviour. Walls may undergo greater lateral displacements if these displacements are produced by flexure rather than by a lateral force only. [Ref no.10].

3. Water Leakage

- **Waterproof mechanism**

The addition of silicane improved the crack resistance, contact angle and the permeability resistance while decreased the water absorption of capillarity compared with control cement mortar, which indicated that the waterproof of modified cement mortar was strengthened generally.

The silicane waterproof materials or traditional waterproof materials have been widely used in the field of waterproof treatment, but most waterproof materials are only coated on the surface of the cement mortar. The repulsive force can be produced at the entrance of pores, and water cannot infiltrate into pores. The hydrophobic film owing a huge molecular volume can prevent the hydration products of the cementitious materials from entering direct contact with the water, which change the hydrophilic properties of the mortar itself. [Ref no.13].

The polyurethane film has excellent adhesion, hardness, flexibility, abrasion and scrub resistance as shown by the results. Water vapour transmission of pcl film has been found to be low, which is an important characteristic of any waterproofing membrane. The polyurethane coating developed can find application for waterproofing of terraces, chajas, pipes and bathroom floors. Cement tanks and asbestos roofing's can be coated with PU resin. Because the film has good resistance to chemicals and salt spray test, it may also be used as an anticorrosive coating for steel structures in biogas and chemical plants. More field trials are required to establish the suitability of the treatment in the different application areas. [Ref no.14].

- **Evaluation of Water-proofness Quality**

If significantly lower dispersion in the measured results of both integral capillarity and diffusion coefficients for basic lining materials than for the coating-lining systems then, most probable reason of this fact is the penetration of the coating into the porous structure of the lining material, which makes a precise determination of the coating thickness very difficult, because we can always get an average value only and have no reliable information about the local values of the thickness.

Main reasons of the application of waterproof coatings on the surface of lining materials is to increase the durability of the lining, as a long-term presence of water in most building materials can damage their structure significantly and have a negative influence on their thermophysical properties. From this point of view, the linings with the more effective, water-repellent Aquafob coating should exhibit a better durability than those with rudicolor. On the other hand, the resistance of the plaster material, Rudicolor, against mechanical influences is certainly better than that of Aquafob. Therefore, the application of Aquafob should only be preferred in the regions where the water-suction problems are dominant in damaging the lining materials. [Ref no.15].

- **Influence of Temperature**

The stress–displacement data gained from the crack–bridging experiments show a decrease in total displacement accumulated prior to failure with decreasing temperature. in this study reveal the initiation, growth and failure of fibril-void microstructures (FVMs) as permanent deformation feature due to temperature variation. A gradual change from brittle to ductile deformation processes occurs which may cause a simultaneous appearance of both brittle and ductile deformation features. The plastic deformation path shortens with slower displacement rate and failure occurs at smaller displacements. Mechno-Structural behaviour depends on temperature, rate dependent stress strain. Water coating film deformation is induced by the rupture of the individual fibrils. [Ref no.16].

- **Water seepage in Concrete**

Concrete is a type of porous material, water can permeate freely into the concrete and that decrease the durability of concrete. Therefore, it is possible to permeate some corrosion inhibitions from the surface of the concrete to inside the concrete due to its porosity. When the depth of the outer corrosion inhibitions penetrate into the concrete is calculated, the linear Darcy Flow is used commonly. But as the low permeable porous material, weather the concrete fit this flow rule should be verified by the experimental results. Otherwise, it will lead to the large errors in calculation. During the service life, concrete structure is subject to different types of damage (mechanical, thermal, chemical, etc.). Generally service damage is not significant enough to cause an important degradation of structural concrete. However, with time, the degradation accumulates and may lead to micro-cracking resulting in permeability variations. The study purpose of this part is to research webilitather the Nonlinear Darcy Flow still fit to the condition of concrete with crack. The water seepage in concrete before ultimate tensile stress was also following the nonlinear Darcy Law. Tensile stress could change the starting pressure gradient (k) of concrete. With the increase of tension, the k decreased. So tensile stress was an important element would be considered in the design of water-proofing concrete. [Ref no.17].

4. Plumbing

- **Maintenance**

Plumbing maintenance plays an important role among other activities in plumbing operation. Plumbing damages and defect are part of the plumbing maintenance. There will be no way to or short cut from plumbing maintenance work. In plumbing and sanitation various components are involved which should be studied, so there is possibility of failure of one or other components. These components can cause a number of temporary problems and also long-term structural damage due to water seepage into the walls and floors. In order to avoid these types of problems it is essential to remedy plumbing issues as soon as they are observed. The durability of a plumbing system is dependent on the quality of its component parts and the assembly skills of those who install it. No plumbing system, however well designed, can be expected to operate safely or hygienically if the products or materials used are unsatisfactory. The inverse is also true if the best quality products or materials are used but are installed incorrectly, the system will be a failure. That's why there proper study and its performance gives optimum success and satisfactorily meets the plumbing expectation. The efficiency and quality of maintenance operation of plumbing depends on the expectation from the house holder, condition of plumbing work which will carried out and its maintenance activity. The objective of this paper reviews is to get the critical success in plumbing maintenance of the proposed building, and enhancing all the perspectives which are stable to get the maintenance of plumbing system.

- **Pipe & Joint Distress**

Pipes (Water Supply Pipes) in market various type of pipes are available such like steel, cast iron, plastic etc. And the most common plumbing problems with water supply pipes are leakages, low pressure, breakage and corrosion of pipes. These problems revolve around two things: material used for pipes, and how pipes are installed by the worker. All piping related problems stem from these two factors.

Leakage in Pipes Leaking pipes are major issues. It not only wastes the water but also affects daily routine of the occupants. Constant leakages through pipes in walls lead to water seepage, which may damage structural components of the building. Leakages may prove to be costly, if the problem is left undetected. For example, the continuously dripping of a tap if left undetected may damage the external surface of wall, plaster, ceilings and destroy paint finishes. Repair of such damage may prove to be expensive. Damage to pipes may occur due to external climatic conditions, which may lead to frosting, thawing, bursting and cracking, or there may be problems like mishandling of pipes on site, poor installation, fittings and joints not properly connected.

3.Results and Discussion

In this paper we accessed maximum papers cognate to civil domains of the building. With the avail of this paper we can relegate the distress in plaster, walls, water proofing & plumbing. When the types of distress are relegated, we will be able to give rating system to each distress, thereby making the study objective. This relegation is obligatory so that audit reports become less subjective.

4.Conclusion

To ascertain less subjective results in the final building rating, inspection workers must be edified and trained in more objective, standardized methodologies and processes.

If different rating is given by different auditors, then it becomes arduous to given final outcome of the audit.

The future of the structure whether to be rehabilitated/repair or demolished is dependent on the conclusion of the Audit report. Exhaustive technical investigation should be utmost priority. Divergent opinions cause's conflicts and we are not able to decide the initial steps in the direction of prosperously consummating the project. If initial procedure

is not felicitously diagnosed then after all it will lead to the failure of the structure.

5.Future Scope

During the life of a structure, repairs, maintenance, and rehabilitation are all obligatory. Neglecting or evading the same can lead to a loss of structure, which can lead to human life loss. The most widely utilized parameter/system is structural audit, which provides precise structural information on the structure's insight.

A standard system must be devised that will accommodate as a protocol for assessing the degree of deterioration of the structure.

This standard system must include uniformity which will be followed by all the auditors.

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