Protection of Buildings from Ingress of Moisture

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Abstract- **Building health and its safety mainly depends on the specifications adopted and workmanship, but one more parameter is important i.e. the moisture levels present in the building structure or in subsoil beneath around the foundation. Continuous presence of excessive moisture in structures starts damaging paint, curtains, wood work, electrical wirings, fixtures, mild steel reinforcements and house hold goods. Varying moisture condition in subsoil affects its bearing capacity of soil for holding structure load as different moisture content in the soil has different bearing capacity. If structure is not properly designed for probable partially or fully submerged conditions the structural safety may be endangered. On the other hand due to moisture in superstructure, growth of fungus, mushroom and bacteria creates unhealthy environment for the residents and users. In the warehouses the moist conditions of the sheds or structures badly affect the quality of food grains stored in it which is spoiled to the large extent. Similarly, if the building was chemically treated for anti-termite treatment, its effect will be lost due to dilution of chemical solution, if water table rises up to the ground level. In view of the above, it is necessary to protect building structures from any type of excessive moistures present in it. All necessary measures should be adopted to safeguard buildings from ingress of moistures. The causes of moisture movement in building mainly are; poor ventilation, defective DPC, terrace or vertical gardening, poor workmanship of concrete works, improper sealing of joints of water supply pipe lines and sanitary installations, cracks, poor slope for rain water flow on roof terrace and providing inadequate no of rain water pipes. Other reason for moisture ingress are RCC roof surface exposed to sun without water proofing treatment, heterogeneous concrete mix used in RCC works, improper water proofing of sunken floors of bath and kitchens, improper filling of tile joints in toilets, damage of water proofing treatment due to aging or UV rays effects and improper water proofing of basement floors. Inadequate slopes of sunshade, clogging of rain water pipes, growing plants on roof or near outer walls of building and poor maintenance of buildings leads to moister presence in the buildings. The methods and procedures adoption to avoid moisture movement in the structures is of paramount importance for healthy living conditions. Innovative R&D technologies and systems are now day's available, for which proper guidance, trainings are essential prior to application. Remedial measures for different geological, climatic and seismic zones conditions are different, which needs the specific precautions. The matter addressing the related problems and possible solutions are being discussed herewith in this article.**

I. MAJOR PROBLEMS

a) Excessive Moisture Content Surrounding of Buildings

The buildings constructed near sea shore, mainly faces this type of problems. Sometimes areas are affected by coastal flooding, due to which moisture rises above ground floor level in the buildings. Under such situation the super structure walls absorbs the moisture, even though proper damp proof course up to plinth level is provided. On the other hand, in coastal areas air remains very humid, resulting protection of structure from corrosion of reinforcement and steel items is the biggest challenge in these coastal environments. Corrosion of reinforcing steel is one of the most important causes of deterioration of concrete structures in the coastal region. Use of high permeability concrete, poor design detailing, construction defects, inadequate depth of cover allow the ingress of salt and moisture into the concrete. A high concentration of salt and moisture causes accelerated corrosion of reinforcing steel and significantly deteriorates the concrete structures. However the NCC (National Construction Code) 2019 Volume II contains the requirements that need to be followed to protect the coastal home from corrosion. The main requirement includes the use of higher grade concrete or specially treated materials that are designed specifically for marine environments. The following materials may be used in construction works;

I. Use of color bond Ultra Steel or Stainless Steel products for the roof, walls, downpipes, fascia, and gutters.

II. Use of powder coatings applied on all aluminum door, window, and fly screen frames.
III. Use of galvanized steel for the building structure.
IV. Use of marine-grade stainless steel for any guard and handrails.
V. Use of M4 class masonry mortar.
VI. Use of anticorrosive paint application over reinforcement before use.

b) Poor Ventilation in the Rooms
Ventilation includes the following factors;

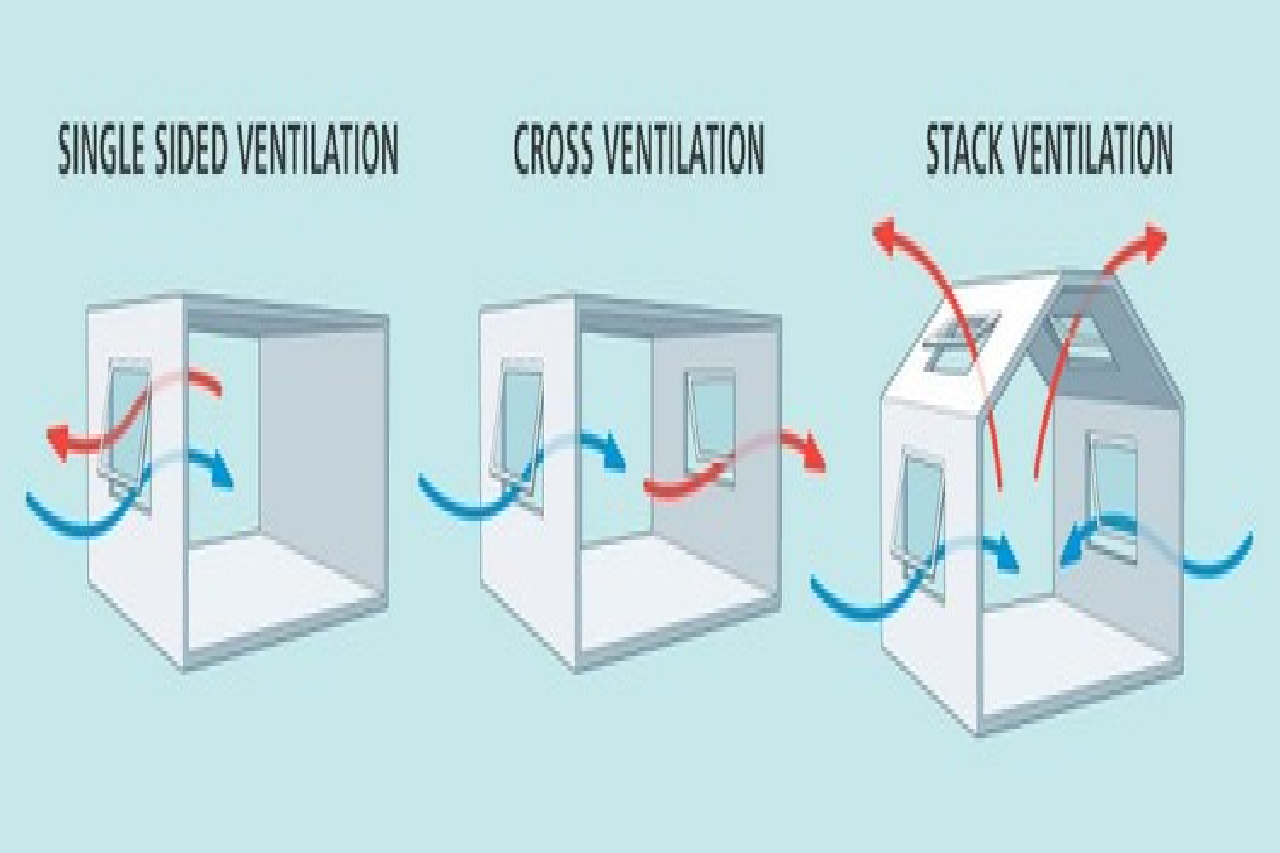
- Indoor air movement and its dilution by mechanical or natural means.
- Filtration by HVAC systems or in-room air cleaners (portable or fixed in position).
- Air quality treatment with Germicidal Ultraviolet systems

II. TYPES VENTILATION

i) Natural Ventilation
Natural ventilation is an environment friendly system that does not require any type of mechanical solution. Natural ventilation is cost-efficient, and relies on natural weather, environmental conditions and architectural design solutions. It may be single sided ventilation, cross ventilation, stack ventilation and chimney effect

Single-Sided Ventilation
Single sided ventilation is the use of openings on one side of a building. This is used to naturally ventilate the space of projects with limited area. Single sided ventilation systems are also used in projects where cross ventilation cannot be provided, due to structural or environmental constraints. Keep in mind though that this type of ventilation generates the least air circulation when it comes to natural ventilation systems.

Cross Ventilation
Cross ventilation is when the openings in a structure are arranged on opposite or adjacent walls, allowing air to enter from both sides, cross the space, and exit from the opposite direction. This system is usually used in buildings located in climatic zones with higher temperatures, as it creates constant air renewal within the building, reducing the internal temperature.



Stack Ventilation

Stack ventilation introduces cooler air from the outside into the building at a low level, which gradually becomes warmer as it gets exposed to heat sources within the space. This causes the now-warm air to rise and leave the space through openings situated at a higher level. Usually, stack ventilation is more effective in tall buildings with central atriums, but can also be useful in buildings where cross ventilation is not able to penetrate sufficiently throughout the space. In order for this ventilation system to work properly, the indoor temperature has to be higher than the outside, which is why it may not always be efficient enough to use on its own.

Chimney Effect

In vertical buildings, the chimney effect is constantly used. Cold air produces pressure under the warm air, forcing it to go upwards. In this case, however, opened areas in the project's center or towers allow that same air to circulate throughout the indoor environment, leaving through the roof, clerestory, zenithal openings, or wind exhausts.

flows of air, natural light and temperature

c) Defective Damp-proof Course

Main defects in the DPC are observed in the form of porosity of DPC concrete layer, cracks in it and heterogeneous water proofing chemical mixing, improper mix design. Discontinuity in water proofing layers during construction and improper overlap joints in the vertical DPC. The specifications and code of practice recommendations should be followed properly. Most of the time there are major moisture problems on external walls if, the ground level outside is above the DPC level. In such cases, RCC walls from foundation to plinth level may be preferred.

d) Vertical gardens grown on the walls.

To protect environment and maintain sustainability sometimes vertical gardening on the external walls of the structure / high rise buildings are provided. The growth of plants needs moisture for which continuous water pouring is needed. If the structure is not fully water proof or cracks are developed at later stage due to weathering effect, this

will make the external walls moist. These problems should be addressed during construction for water proofing and durability of structure.

d) Improper jointing of plumbing and sanitary fittings

It is commonly observed that many times the plumbing and sanitary fitting joints are not properly sealed, resulting leakage from joints. If, the pressure water supply pipes are not properly jointed and are concealed in walls, slabs or sunken floors then rectification of defects and maintenance of pipe line is a difficult task without dismantling the concealed area. On the other hand, leakage and seepage problem also engrave the situation. In non pressure pipes horizontal joints are more venerable as compare to vertical pipes. In vertical pipes water go down easily hence problem is low but in horizontal pipes it retains for longer time and leakage and seepage problems are created drastically. Pipe and fixture jointing should be properly sealed and checked before concealing in order avoiding future problems.

e) Structural defects

Structural defects like poor workmanship of construction, poor quality of concreting, improper construction and expansion joints, cracks in structural members provides way to enter the rain water, which may cause the dampness in the structures. Poor workmanship not only affects the aesthetics bur also causes corrosion in reinforcement, carbonation of concrete, porosity, sagging and lower strength of structural members. This type of defects should be minimized by taking appropriate measures during planning and execution stage.

f) Inadequate size of gutters in sloped roofs.

Usually, in sloped roofs of buildings such as industrial buildings or commercial buildings, workshops etc. the gutters are provided to collect the rain water and discharge through the rainwater pipes. If the size of gutter is smaller than required, the water will stagnate and splash over the gutter in case of heavy rainfall, the moisture from gutters may enter into the surrounding walls creating moist and unhygienic conditions. This problem may be avoided by designing and adopting proper size of gutters and rain water pipes.

Inadequate Gutters Size

g) Increased ground water level during flooding conditions

When the building plinth level is lower than the flood water level the moisture enters in the super structure and causes the moist conditions inside the building. This condition may be eliminated by improving drainage conditions of the area or proper site selection beyond high flood level.

h) Porosity in external plaster

When graded sand is not used in plastering the plaster become porous and chances of ingress of water on external walls is enhanced. To avoid the porosity proper bonding, mix proportion and finishing is needed. Sometimes rough cast plasters are applied on external walls, it restrict the smooth flow of rainwater on external wall surfaces. It may also be a cause of moisture in the buildings.

i) Untreated separation joint

Separation or expansion joints are provided to accommodate the deformation of buildings due to temperature change, seismological reasons, vibration or settlements. The gap provided between buildings should be properly treated by suitable flexible materials so that the moisture could not enter in the building walls through these gaps.

j) Grooves in decorative plaster finishing

Grooves are marked on external plaster for making decoration patterns for providing good aesthetic look. These grooves, if not properly treated may become a source of water entry in the building during rains. Obstruction to rainwater flow on walls provides retention to rain water for a longer time and may become the cause of humidity/ moisture in the buildings.

k) Insufficient cement concrete cover on the top of ceiling fan box, light box and electric junction boxes in RCC slabs

Now a days, fan box, light box and electric junction boxes in RCC slabs are provided as concealed fixtures. If the thickness of the slab is less i.e. 100mm to 120mm the top cover on the top of fixture remains very less and this thickness of cover may not be sufficient to protect the rain induced moisture. So, extra precautionary measures are needed on these points to save the fixtures from moist conditions. This problem is more prominent in roof slabs if water proofing is not properly laid.

l) Drains along external walls or inadequate plinth protection of the buildings along external walls

Sometimes due to lack of space waste water open drains are provided along the external walls of buildings. With time the joints and plaster of open drain due to weathering conditions start damaging and create cracks in its side walls and bottom of drains. This leads moisture movement in foundation of the building and enters in the super structure if water proofing treatment is not proper. This creates moist and unhygienic conditions in the buildings. On the other hand foundation settlement can take place. It is therefore suggested, open channels or drains should be provided after providing plinth protection i.e. away from the buildings.

j) Tree plantation in the vicinity of buildings

Trees adjoining to the buildings when grows higher its roots also grows and roots try to enter in building external structure and develop cracks. These cracks help moisture movement in the buildings. Therefore, the tree plantation should be at certain specified distance from external face of the building as per their varieties and growth pattern. On the other hand, trees near building obstruct the flow of rain water due to falling of foliage on the roof tops (if the building is not high rise).

k) Poor maintenance of the buildings

Proper maintenance of the building as per requirements is essential. Maintenance keep building in a healthy conditions and risk of development of cracks, growing of fungus on external surfaces, growth of wild plants and grass, loosing bond of plaster with external walls due to weathering effect is eliminated. Deterioration of building structure health and life may be protected to a great extant. Timely and proper maintenance provides protection against structural damages, entry of moisture in building through cracks in rainy season, reduction of the value of property, health and structural safety risk and aesthetic look.

l) Types of sunshades with facias

Sunshades and facias are constructed to protect building from entry of rain water and direct sun light in the buildings. Its shape and workmanship plays a vital role in proper control of moisture movement in the building. Facias are provided for improving aesthetic looks of structures but they always obstructs the flow of rain water. To avoid this proper diameter of rain water pipe or spouts should be adopted so that their clogging problem may be solved. Sun shades also needs proper slope for easy flow of rain water. In the back side of sunshade the beam level should be higher than the thickness of sunshade to stop the entry of back flow of water in to walls.

m) Low concrete cover to reinforcement

The concrete cover to the reinforcement should be provided as per requirement of weathering conditions as per standards and codes recommendations. If the standards are not properly followed in moist weather conditions reinforcement may corrode. It will lead structural health issues and safety issues. If the cover to reinforcement is provided of proper thickness the risk of carbonation of concrete up to reinforcement may be eleminated.

n) Shrinkage or structural cracks

Cracks are main source of water entry in the structure whether these are shrinkage, structural and settlement cracks. Shrinkage cracks may be minimized by keeping water cement ratio in the permissible limit, use of plasticizers, temperature control and quality control during execution. Other cracks may be controlled by proper planning, design and workmanship. If, the cracks are being developed due to weathering conditions, the cracks may be sealed by using appropriate technology. Cracks in RCC may be minimized by using fibre reinforced concrete.

o) Improper roof slope for proper drainage of rain water

Different types of roof surfaces need different gradients. In case the roof slope is less than the needed, water on the roof will remain standstill, which flow very slowly and retains for long time hence leads to moisture movement in the roof members. This is a main cause of leakage or seepage in the building from the roof. To avoid this situation at least minimum roof slope should be provided as recommended by national or international standards. Proper slope become more important in slow fall areas for easy sliding the snow from roof surfaces.

p) Providing insufficient rain water pipes

Rain water pipes functions are to collect the rain water from roof or gutters and carry to the rain water drain or rainwater harvesting areas. In many cases it is seem that either the pipes are provided with lower diameter or number of pipes is reduced. This is a critical condition, during the heavy down pour either the rain water over flow on the gutters or start stagnating over the roof surface. Under this condition water starts penetrating in to structural

members even passing through waterproofing on the surface. A careful design of rain water pipe sizes and location is necessary to overcome the associated problems. Proper sealing the joints are also equally important.

q) RCC roof surface exposed to sun

In case RCC roof surface exposed to sun particularly in hot regions without insulation and water proofing treatment the temperature cracks on the concrete surface are developed. These cracks are more venerable, if the temperature reinforcement is not provided during casting of roof slab. These cracks weaken the structural members and provide easy path to pass the water through it. The fiber reinforced concretes are observed with minimum cracking tendency during contraction or expansion under the varying temperature.

r) Heterogeneous concrete mixes in RCC work

Heterogeneous concrete mixes does not provide proper bond in itself and with steel reinforcement provided. The chances of cracking and failure of such structures are high. Such structures are somewhere porous and somewhere dense. Their thermal expansion and contraction in the same members are different. The porous areas are more venerable for water susceptibility and ingress water in structural members.

s) Terrace garden on roof without proper treatment

Terrace gardening is the new trend developing now a days. It is environment friendly for the residents that provide fresh oxygen and natural look. It is good for healthy conditions around us. Contrarily, it affects the service life of the buildings due to continuous presence of moisture. The building should have very efficient drainage system and proper water proofing so that the ingress of water in to structure do not take place. Similar precautions are necessary for vertical gardening also.

t) Improper water proofing of sunken floors of bath and kitchens

Sunken floors are depressed floors made for adjusting water supply and drainage pipe lines of bath, kitchen sink, wash hand basins, traps and WC waste etc. below the normal floor level. These sunken floors often seen moist due to the following reasons:

- Improper horizontal and vertical water proofing of sunken floors.
- Leakage through water pipe lines.
- Improper sealing of water supply and sanitary installation fixtures.
- Improper filling/ sealing of tile joints in toilers.
- Damaging of water proofing treatment of sunken floor.
- No provision of water drainage of sunken floor if, filling material in it is fully saturated.
- Decay of water proofing due to aging or weathering.

A very careful supervision during construction are needed to protect sunken floors from ingress of moistures. Proper sealing of horizontal pipes is little difficult and should be done properly. Smoke test should be conducted to detect leakage chances before concealing the pipes, fittings and fixtures in sunken floors.

u) Sagging of RCC roof slab

Sagging of roof slab may take place if proper grade of concrete is not laid during execution due to poor mix design, improper mixing, compaction, segregation and high water cement ratio or weathering effect. After sagging some depressions are formed on the top surface of the slab and rain water flow is obstructed. Rain water is accumulated in the depressions leading to moisture movement in the structures. To avoid this type of problems proper design and strict supervision during execution is needed.

v) Damage of water proofing treatment

There are many reasons of damaging water proofing layers on the roof surface. It may be due to abrasion, impact load, aging or UV rays effects on organic materials such as bituminous felts, polymers and rubber based sealants. A proper assessment of water proofing layer from time to time is essential. Appropriate remedial repair work should be completed as and when any damage is reported.

w) Improper water proofing treatment of basement

Construction of basement in any building is a complex system which involves hydrological, geotechnical and structural issues. Health safety and waterproofing expertise with sufficient experience is needed during planning and execution stage. Encountering water table is also a great challenging work during execution. At every stage adequate safety measures are required. Basement is an underground construction, which needs walls and floors of basement fully damp proof to prevent the moisture movement inside or within the walls and floors of the structure. Basement works can be single level basements or multi-level.

III. CONCLUSION

Moisture management in buildings is critical for ensuring the structural integrity, longevity, and health of the occupants. Excessive moisture presence can cause significant damage to building materials, electrical systems, and personal property, while also fostering the growth of mold, fungi, and bacteria, which can lead to unhealthy indoor environments. The primary sources of moisture ingress include poor ventilation, defective damp-proof courses, improper sealing of plumbing and sanitary fittings, structural defects, and inadequate waterproofing treatments.

Effective moisture control strategies must address the unique challenges posed by different environmental conditions, such as coastal areas where high humidity and salt can accelerate corrosion of structural elements. Implementing high-quality construction materials, such as marine-grade stainless steel and anticorrosive treatments, and adhering to proper design and construction practices are essential.

Natural and mechanical ventilation systems play a vital role in controlling indoor humidity levels. Proper ventilation design, including options like cross ventilation, stack ventilation, and the chimney effect, can significantly enhance air quality and reduce moisture-related issues.

Regular maintenance and timely repairs are crucial for preventing moisture problems. This includes ensuring proper slopes for roof drainage, adequate gutter sizes, and effective waterproofing of basements and sunken floors. In regions with heavy rainfall or flooding, site selection and drainage improvements are necessary to protect buildings from moisture ingress.

In summary, a comprehensive approach to moisture management, incorporating advanced materials, innovative technologies, and diligent maintenance, is essential for safeguarding building health and providing a safe, comfortable living environment for occupants.

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