

Causes of Building Collapses

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ABSTRACT

The majority of building collapse incidents that occurred between 2021 and 2025 took place in the hottest months of the year (summer), particularly in the world's hottest regions. This indicates that the primary cause of the collapse is variations in the volumetric expansion rates of the materials that make up the building's structure. For instance, although not exactly the same, the volumetric expansion of concrete is getting close to that of the steel utilised for reinforcement. As a result, in huge buildings that use a lot of steel and concrete, the rates of expansion of the two materials differ greatly, particularly when temperatures are high. Because concrete is brittle and lacks ductility, this causes steel to expand more quickly than concrete, resulting in cracks in the concrete's microstructure that ultimately cause the building to collapse. Meanwhile, because temperature has a significant impact on chemical reactions, the rate at which water escapes from the concrete composition increases at high temperatures. This causes the concrete to become brittle, shrink excessively, and lose its original qualities.

Purpose: Determine the causes of building collapses and take action to stop them.

Method: gathering information on building collapse accidents, including dates and circumstances, and examining the physical characteristics of building materials to find elements that contribute to a building's longevity.

Results: Since it is now evident that global warming significantly affects building safety, building designs should incorporate the need for these emergency developments brought on by exposure to hot solar radiation. Thermal insulators are one of the key components of the basic design of buildings to lessen the effects of heat transfer from the parts that are exposed to the sun on the rest of the building, as well as to prevent the disparities in the rates of expansion of the external and internal parts of the buildings.

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Introduction

The study intends to look into the causes of building collapses and find solutions, such as lowering the impact of sun exposure during the summer and improving building designs to fit global weather conditions. It also focuses on certain mistakes that lead to buildings collapsing because maintenance workers use incorrect techniques while performing their duties, and it improves traditional designs to prevent conflicts arising from variations in the expansion rates of the different sides of build. For instance, extensions of each floor's concrete layers that reach the building's exterior, like balconies, since a building's exterior (balconies) expands more than its interior (rooms) as a result of exposure to solar radiation. Because of their varying temperatures, each piece of concrete on the floor of each stair will experience varying rates of expansion and contraction; high tension is created in the spaces between them, resulting in cracks in the concrete layers of each stair; this expansion and contraction happens repeatedly every day with the temperature difference during the day and night as well as during the temperature difference during the four seasons. In the interim, utilise thermal insulation [1] and thermal reflectors [2] in

the building's external sections to lower the building's exposure to sunlight and the amount of heat it absorbs. Use a single central air conditioning system [3] for every building, positioning its equipment appropriately on the ground to prevent adding weight to the structures and preventing vibrations, which are the main source of energy that causes concrete fractures. When constructing the concrete mixture under quality control to meet the necessary criteria, the specifics of the employed cement's ingredients should always be evident to determine how much sand has to be added. Cement made from the debris of concrete constructions is one of the many varieties of cement that are sold in the marketplaces [4]. Because of the low ratios of metal oxides to the proportions of the existing sand, this type of cement contains large amounts of sand, which will increase the rate of sand and cement during the creation of the concrete mixture. This lowers the cohesion strength of the concrete and shortens the lifespan of the built structure. By adhering to these criteria, taking climate change into account, and attempting to adapt to the necessary advances through better designs, we may be able to construct structures that can withstand the current circumstances that lead to building collapses.

The best method for determining the causes of building collapses is to pick one incidence and look into it from every angle to

determine the causes of this phenomenon, which has been more prevalent recently due to the increase in environmental heat brought on by global warming.

Investigate the issue of collapsed buildings: Building collapses have caused several accidents, particularly in the past ten years. Although there are numerous causes for these building collapses, we can identify the majority of them as follows:

One of the most frequent causes of building collapses is fissures in concrete structures, which may be better understood by knowing how cement is made and how concrete structures are formed.

Therefore we should first understand the reasons behind these cracks and that may possible via understanding the chemistry and physics of concrete material, Portland cement clinker (K): The definition given in ENV 197–14 is that the Portland cement clinker is a hydraulic material which shall consist of at least two-thirds by mass of calcium silicates ((CaO)₃·SiO₂ and (CaO)₂·SiO₂), the remainder containing aluminium oxide (Al₂O₃), iron oxide (Fe₂O₃) and other oxides. The ratio by mass (CaO/SiO₂) shall not be less than 2.0. The content of magnesium oxide (MgO) shall not exceed 5.0 per cent by mass. Portland cement clinker is made by burning, at least to sintering, a precisely specified mixture of raw materials (raw meal, paste or slurry) containing CaO, SiO₂, Al₂O₃ and small quantities of other materials. The raw meal, paste or slurry shall be finely divided, intimately mixed and therefore homogeneous [5] due to the high chemical efficiency and the water liquefaction of these oxides, after the processing of the concrete mixture these minerals oxides got mixed with the water the result product (the concrete structures) has a very high mechanical properties and suitable to be used for construction purposes, after the completion of mixing and pouring the concrete into the building blocks and after it get hardens, when the surface of concrete dries, water evaporates from the spaces between particles, as this water dissipates, the particles move closer together, resulting in shrinkage of the concrete, because the surface of a concrete slab is exposed to air but the underlying concrete is not, concrete near the surface dries and shrinks at a rate different from that of the underlying concrete, and acts as a restraint to shrinkage resulting in cracking of the surface layer [6]. The concrete begins to shrink as a result of the gradually releasing of water molecules from the formed molecules of the concrete composition, and this shrinkage in the concrete size continuous due to the continuous releasing of water molecules and the continuous of the shrinkage the concrete size and this leads to the create of cracks all around the concrete structures, especially due to the used iron grids in the concrete structure has stable size and dimension and could not change during the shrinkage of the concrete, it is possible to restore and repair concrete blocks that suffer of cracks by injecting concrete mixture among these formed cracks, but this may only possible in the limited period (several years), but when these cracks grows to a dangerous limits, the building should be evacuated and demolished due to the high rates cracks because that could not be fixed. There are many factors that encourage the formation and growth of cracks in concrete, such as non-compliance with technical standards in choosing the appropriate materials for construction.

Investigating the incident at Champlain Towers South [7] is the best example in this study:

Choosing this accident of The Champlain Towers South represents explaining factors that guide buildings to collapse: The Champlain Towers South building suddenly suffered a partial progressive

collapse at about 1:25 a.m. EDT on June 24, 2021, when this isolated and destabilised part of the northeast corner of the building also collapsed approximately nine seconds later. Of the 136 units in the building, at least half were destroyed.

General data in respect to this building: Floor count 12 (plus rooftop penthouse), Height 42.5 m, material reinforced concrete, completed 1981, demolished July 4, 2021

We can estimate the amount of tension created in the areas connected to the other sites that had no expansions, like the inside of the concrete, by calculating the expansion rates in each part that is exposed to the sun. However, we need all of the building's dimensions, including length, width, height, distance, area, and volume.

Since there is no data for this building, we will only perform the necessary thermal expansion calculations for the Florida building's height, which is 42.5 meters, in order to determine the building's front face.

Where the rest of distances of the building, as length, width, height, distance, area, volume is also important and that may be done by the inspectors whom working may have this information in respect to this building and now to investigate the accident of the collapse of this building, to calculate the total expansions of the length, width, height and camper the result with the original dimensions of the building. to find the rates of tension which been created in the area connected with the inside parts of the building which didn't expand due to their location which protect them of expose the sun ray in the day hours in the summer, also may calculate the rates of shrinkage of the inside parts due to the reduction of the rates temperature due to using the air conditioner equipment, and estimate the length of balcony 30 m we could calculate the expansion rate of each balcony to find the rates of the tension which been created in the area connected with the inside of the building:

The Expected Reasons

The variety of thermal expansion of Iron and concrete: Thermal expansion refers to the way in which any given substance, either gas, liquid, or solid, will undergo modifications of shape, volume, area, and length as temperatures vary. Their expansion is caused by particles expanding or contracting within particular substances according to different temperatures. There are three forms of thermal expansion:

- a. Linear thermal expansion.
- b. Areal thermal expansion.
- c. Volumetric thermal expansion.

Calculation of the linear thermal expansion [8] of the length of the object is dependent on temperature. Therefore, if we heat something up or cool it, the length changes in proportion to the original length and the temperature changes.

$$\Delta L = \alpha \times L \times \Delta T \dots\dots 1$$

Where:

ΔL = the variation in object length (meter).

L = the original length of the object (meter).

α = the linear expansion coefficient of concrete $1/^\circ\text{C}$ (CTE).

ΔT = the change in temperature $^\circ\text{C}$ is the change in temperature in for front facade

The linear thermal expansion coefficient (CTE) is dependent on the linear thermal expansion and is most applicable to solids using the length change per degree per unit length in $(\text{mm}/^\circ\text{C})$.

Calculate the length change the front facade of the building $L = 42.5 \text{ m}$,

α is the linear expansion coefficient of concrete = $12.0 \times 10^{-6} \text{ }^\circ\text{C}$

$$\Delta L = \alpha \times L \times \Delta T$$

$$\alpha = 12.0 \times 10^{-6} \text{ }^\circ\text{C}$$

When the temperature rises from 25°C to 45°C

$$\Delta T = 45^\circ\text{C} - 25^\circ\text{C} = 20^\circ\text{C}$$

L = the original length the front facade is 42.5 meter.

The linear expansion of the front facade of the building ($\Delta L1$) = $\alpha \times L \times \Delta T$

$$= 12.0 \times 10^{-6} \times 42.5 \times (20^\circ\text{C})$$

$$\Delta L = 0.0102 \text{ meter}$$

$\Delta L = 10.2 \text{ mm}$ represents the potential cracks formation

Between interior and exterior of the of the same concrete layer, these differences in the length expansion between the interior and exterior of the same concrete layer create cracks in the building materials in the interstitial zone, between the two different circumstances, the temperature of the material is heated all day long due to exposure to the sun's rays, and the inner sides are cooled by the air conditioner equipment's, in order to calculate the rates of expansion of the concrete layer of the balcony, we may consider that the length of the balcony is about 30 metres.

Calculate the length change of any of the balconies of this building, considering the length is about 30 m, $L = 30 \text{ meter}$, where:

α is the linear expansion coefficient of concrete = $12.0 \times 10^{-6} \text{ }^\circ\text{C}$.

$\alpha = 12.0 \times 10^{-6} \text{ }^\circ\text{C}$ if the temperature rises from $25 \text{ }^\circ\text{C}$ to $45 \text{ }^\circ\text{C}$.

L = the original length of the object in metres, which is 30 metres, to calculate the expansion rates in any of the balconies of the building.

The linear expansion of any of the concrete layers of the balcony ($\Delta L1$) = $\alpha \times L \times \Delta T$

$$\Delta L1 = \alpha \times L \times \Delta T$$

$$= 12.0 \times 10^{-6} \text{ }^\circ\text{C} \times 30 \times (20 \text{ }^\circ\text{C})$$

$$\Delta L = 0.0072 \text{ m}$$

$$\Delta L = 7.2 \text{ mm}$$

Due to the changes in the temperature between 25°C and 45°C , the

difference in lengths between the exterior zone that is exposed to the sunray and the interior zone that is cooled by air conditioning can create tension and potentially lead to cracks in the building materials, especially in connecting areas for the concrete layer of the balcony, assuming a linear expansion coefficient of concrete (α) and a temperature change (ΔT) from 25°C to 45°C . The resulting length change (ΔL) for the balcony is 7.2 mm crack formation in the connecting areas. This is the difference of the length between the concrete layer of the balcony and the concrete in the rooms of the building, and this also creates cracks in the building materials in the connecting areas between the two different circumstances of temperature for the concrete layer of the balcony, which got heated all day long due to exposure to the sun's rays, and the inner sides, which have been cooled via air conditioner equipment, these rates can lead to tension and potential structural issues. If we look at image (1) the photo of the Florida building before been collapsed, specifically on the upper floor and the roof, we find that the balcony and the floor of the building based on one big concrete layer, and that concrete layer from the side of the balcony is exposed to the sunrays throughout the day, while the same concrete part from the side of the rooms is never touched by the sunrays and even the air conditioners are used to cool the rooms, this means that there is a difference in the temperatures between the exterior part of the concrete layer in the balcony and the interior side of the concrete layer the rooms for each floor in the building, when the balcony is exposed to the sun rays of the summer for long hours, the temperatures of the concrete layer will rise to high rates, while the temperatures in the concrete layer of the rooms will remain at low rates, this will lead the concrete layer in the balcony to be expanded to high rates, while there is no changes in the expansion rates of the internal concrete layer in the rooms or may even shrink due to the cooling of the air conditioners, this may create cracks in the concrete layer in the zone between the two different temperature rate of each floor, in the meantime the effect of the weight of the building materials in the balcony will lead to the growth of cracks in the two different temperature zones of each floor due to the difference in expansion rates, and this will result the collapse of the balcony and fails upon the low floors balconies, which also suffers of the same sort of cracks and collapses and this will result as a dominoes falling balconies upon each other, thus will generate a great collision force for the accumulated building materials of the balconies with the ground to generate violent vibration in the ground that leads to collapse of the neighbours buildings. In order to perform the calculations and know the value of the expansion in the concrete layer of the balcony side to the value of the expansion in the concrete layer in the side of the rooms, we will perform this simple calculation to calculate the rate of expansion of the two sides of the concrete layer.

Factor of the Diversity Expansion Rates of used Materials

Concrete expands slightly as temperature rises and contracts as temperature falls, temperature changes may be caused by environmental conditions or by cement hydration (the exothermic chemical process in which the cement reacts with the water in a mixture of concrete to create the calcium silicate hydrate binder and other compounds), an average value for the coefficient of thermal expansion of concrete is about 10 millionths per degree Celsius ($8.0 \times 10^{-6} \text{ }^\circ\text{C}$), although values ranging from 7 to 12 millionths per degree Celsius have been observed. This amounts to a length change of 1.7 centimetres for every 30.5 metres of concrete subjected to a rise or fall of 38 degrees Celsius.

1. Thermal expansion and contraction of concrete vary primarily with aggregate type (shale, limestone, siliceous gravel, and granite), cementitious material content, water-cement ratio,

temperature range, concrete age, and ambient relative humidity of these factors. The aggregate type has the greatest influence on the expansion and contraction of concrete.

2. Severe problems develop in massive structures where heat cannot be dissipated. Thermal contraction on the concrete's surface without a corresponding change in its interior temperature will cause a thermal differential and potentially lead to cracking. Temperature changes that result in shortening will crack concrete members that are held in place or restrained by another part of the structure, internal reinforcement, or the ground. For example, a long, restrained concrete section is allowed to drop in temperature. As the temperature drops, the concrete tends to shorten but cannot, as it is restrained along its base length. This causes the concrete to be stressed and eventually crack.

3. The difference in the values of the steel expansion coefficient and the concrete expansion coefficient [10] in the same building, where steel expansion coefficient [11] is $13.0 \times 10^{-6} \text{ }^\circ\text{C}$ and for concrete expansion coefficient is $12.0 \times 10^{-6} \text{ }^\circ\text{C}$. These little differences may grow to high rate is a very high temperature which may results high rates of expansion in the used iron may threaten the building to collapse, because considering that the temperature difference is 20 due to the high temperature of the outer side which is exposed to sunlight during the summer, note that the coefficient of longitudinal expansion of concrete and the coefficient of longitudinal expansion of iron and of concrete are close to each other, but they are not identical, because iron is a pure metal, but concrete consists of a total of two compounds, so at high rates of temperature the small differences in the rates of expansion are greater, this specific expansion of the relatively high Iron causes a serious crack in the concrete, which eventually leads to the collapse of the building.

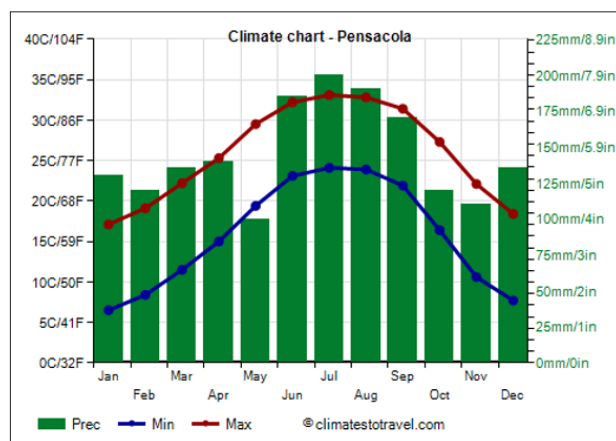


Illustration (1) shows the temperature rates in Florida during the year [12].

These cracks grew due to the vibrations generated continuously by the cooling air conditioner equipment which have been installed above the building, because vibrations is the best energy resource to feed the growth of cracks in the brittle materials, and this led the buildings to the collapse, where these buildings have already been suffered, of expansion at different rates according to the angles of these parts to the angle of the direction of sun ray, what led to the fall of the balconies of the upper floors upon the balconies of the lower floors and the fall continued like dominoes pieces, led to the generation of a great collision force on the ground generating a violent vibration caused the collapse of the neighbour building, note that the building had been undergoing on these mentioned conditions of expansion and shrinkage at different rates and the vibrations for forty years since the date of construction in 1981, where the cracks were forming and growing in the structure of the concrete as a result of the shrinkage as natural effects due to losing water of the concrete.



Image 1: is the photo of the Florida building before it collapsed.

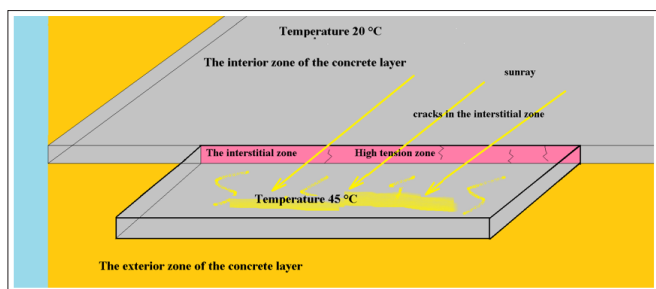
The main reasons for the building collapse: all parts of the building from the inside were in a state of shrinkage due to continuous cooling by air conditioner equipment, while most of the outer parts, such as the roof and the front facade, were in a state of expansion due to heat which remained in the material of the building as a result of their exposure to the sun's rays for long hours, therefore the interfacial areas that separate the expansion and shrinkage areas suffered from high tension due to the changes in the volumes of the material around, which led to the creation of cracks in the building materials.



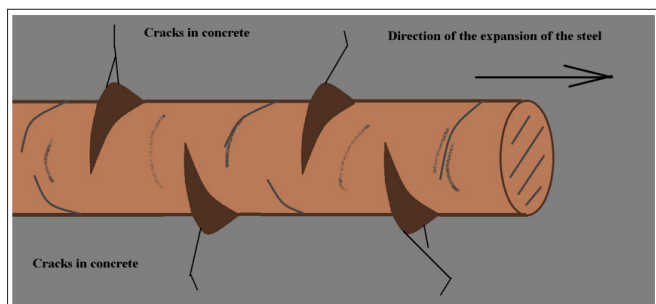
Image 2: Photo of the Florida building during the incident. [13]

According to traditional chemistry principles, there is an inverse relationship between two temperatures and the time required for the reaction to occur, and this indicates the extent of the danger of high rates of temperatures in buildings in the temperatures, to the 40 °C to the exposure of those buildings to sun rays many hours in the daytime during the summer, means the occurrence of the same chemical reactions in the reactor of the production of cement where the water removed from iron and aluminium components using the high temperature, therefore, materials of

the building lose their mechanical properties when exposed to heat for a long period, which causes cracks that result from the reduction in the original size of the concrete, where the extra added the heavy weights placed on the building feeds these cracks is such as the cooling and air conditioning equipment's, which also generate vibrations during their work and these vibrations in the cracks feed the growth of the cracks in the building which results the collapse of the building, note that in hot countries such as Africa and Asia as well as any another hot countries, people cannot even touch buildings after being exposed to sunlight for several hours during the day, because of their extreme heat and that heat remains in those buildings for a long time after sunset and even many hours after at midnight. These differences in the length expansion between the interior and exterior of the same concrete layer, as shown in illustration (2) create cracks in the building materials in the interstitial zone, among the two different circumstances, the temperature of the material is heated all day long due to exposure to the sun's rays, and the inner sides have been cooled by the air conditioner equipment.



The illustration (2) shows the effect of the difference in expansion rates of the concrete layer for the interior and exterior zones of the building to form a high-tension zone, which leads to the creation of dangerous cracks in the interstitial zone that lead to its collapse.

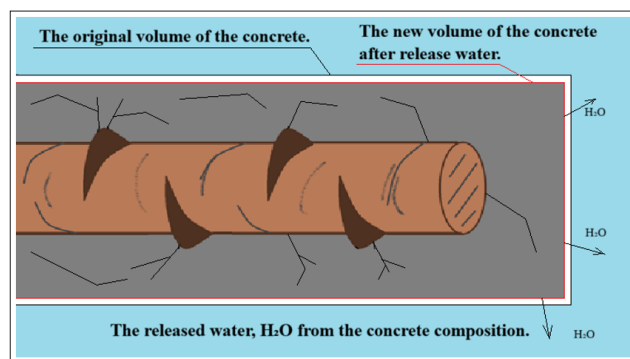


The illustration (3) shows how cracks occur in concrete due to an increase in the rate of expansion of Iron over the rate of expansion of concrete, especially in large buildings that use large amounts of iron and in high temperatures.

Errors in the design of the Florida buildings

We find the balcony for each unified floor with a length of about 25 metres, which means the expansion rates in the concrete layer on the balcony side are very high due to high temperatures and exposure to sun rays for a long time, and this creates a serious threat to the structure. Cracks in the area between the concrete layer on the balcony and the concrete layer of the rooms, in the meantime, the balconies were not supported by supporting columns to reduce the effects of the weights of materials on the balconies, as we find that in modern frontal designs, because these supporting columns reduce the stresses on the fulcrum point with the main part of the concrete layers due to the torque generated by the weights of building materials and their distances of the torque points,

which may prevent occur cracks, and the presence of weights above the upper ceiling of the building, such as air conditioning and refrigeration equipment. The presence of weights above the upper ceiling of the building increases the total weights of the building materials and increases the generated stresses, which result in cracks. Therefore, no extra weights should be placed on the upper roof of the building, such as the air conditioning equipment, and it should be replaced with a central cooling system for the building, which should be installed in a safe place on the ground to avoid any extra heavy weights and also avoid the effects of their vibrations on the building.



The illustration (4). The contraction in the volume of the concrete due to the release of water from its composition results in cracks, especially around the rest of the materials, which did not change their volume, such as steel or stone.

Suggested Solutions

1. Support buildings with supporting columns: Supporting buildings with supporting columns to reduce the impact of the weight of materials on the balcony, as we find this in modern door designs.
2. Thermal insulation: Global warming is one of the factors for collapsing buildings, therefore thermal insulation should be considered and daytime added to the parts of buildings that are exposed to high rates of sun rays during the daytime in the summer, especially in hot countries.

How to reduce thermal expansion: There are several ways to reduce the effect of thermal expansion we can try to:

- Consider the global warming and scorching solar radiation during the design of the building.
- Avoid designs that include extensions of the building outward to prevent different exposure rates to sunrays and different expansion zones.
- Reduce exposure to heat sources.
- Consider the thermal stabilization and thermal insulators as part of the building.
- Reduce the differences between the rates of heat expansion (choosing suitable materials).
- Take into consideration the colours of the building when designing, as light colours reflect heat more than dark colours.

Committed to the Basic Scientific Principles

The basic scientific principles should be considered in building design, and be adhered to regardless of the developments of engineering designs and the quality of building materials where all constants, variables and probabilities of design should be taken into consideration to make a dependable environmental,

able to do their functions in all environment circumstances, including the calculations of the torque generated in each corner of the building as a result of the weight of the materials and the distances of the centre of the weights from the fulcrum point, because the development of the quality of materials cannot replace the stresses generated as a result of the increase in the torque generated of the weights of building materials of the building and their distances of the torque points, nor able to solve the issue of the cracks that are created as a result of the differences of expansion of building materials due to different temperature conditions. In modern designs of buildings, the climatic changes and the turbulent increase in temperature rates should be taken into consideration by making modern designs avoid the existence of extensions in the concrete layers which may expose the high rates of sun rays, such as the absence of the balcony or any part of the concrete slabs which may be more exposed to temperatures than the other internal sides, in order to avoid the disparity in the rates of expansion and contraction in the construction which causes cracks in the construction which results in the collapse of the building. According to the data of the building and the accident of the collapse, at the moment of the building's collapse, at about one o'clock at night, when the refrigeration equipment was working to cool the rooms, and the temperature on the inner side of the building was about 16 degrees Celsius, this disparity between the rates of contraction and expansion of the inner sides and the outer sides of the building led to the growth of the cracks that formed and grew about forty years ago since the starting date of the building of the foundation as a result of concrete contractions, led to formation of dangerous cracks in the facade of the building and the concrete layers which led finally the building to collapse. As shown in the image (3), one of the modern designs of buildings that use columns to support balconies, and this prevents the generation of torque in the material of the balconies, which leads to the creation of dangerous cracks in the interstitial zone and can result in building collapse. These tensions create cracks in the interstitial zone between the interior and exterior zones of the concrete layer and represent a high-tension zone, preventing the creation of tensions and cracks and preventing the balconies from falling, and increasing the building's lifespan.



Image 3: One of the modern designs of buildings that uses columns to support balconies.

Image (4) shows a model of modern buildings where we do not find any parts extending from the inside to the outside, such as balconies. This guarantees that the expansion and contraction rates of the building material will not vary; this prevents the generation of stresses and the creation of cracks. Note that even the light colour of the building reflects the sun's rays, which reduces the effect of solar heating during the summer to stabilise the temperature of the building.



Image 4: Shows one of the modern buildings without any extending parts from the inside to the outside such as balconies

Building Collapse during the Maintenance

There are also many other examples of building collapse, including the damage to the concrete foundations due to the corrosion of reinforced Iron via the rust factor in the concrete casting that creates cracks in the concrete layers, where corrosion of reinforced Iron occurs over time by exposure to environmental conditions, especially in the high-humidity regions in the world, causing corrosion of reinforced Iron within the concrete structure, where the rusting of the Iron weakens its structural integrity and threatens the overall stability of the building.



Image 5: Shows Iron rusts in concrete

There are several ways to treat this problem, such as jacketing, which is a way of structural retrofitting and strengthening used to boost bearing load capacity following an amendment of the structural layout or to repair structural design integrity due to a failure within the structural member.



Image 6: Jacketing has advantage of increasing the member stiffness and is useful where deformations are to be controlled, and this design for strengthening is based on composite action between the old and new work because it's the issue of strengthening and retrofitting of existing structures, this method of maintenance is safe and does not endanger the safety of the building during maintenance [14]

There is also another way to reinforce foundation columns by replacement of corroded steel [15] to replace the rusted iron with new reinforcing steel in the process:

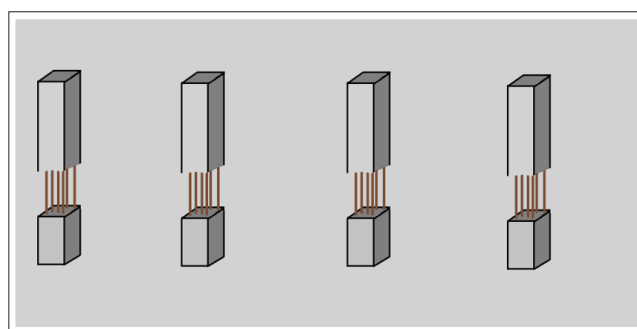
1. Replacement of corroded steel: Remove and replace the reinforcement steel affected by corrosion.
2. Additional reinforcement: Add additional reinforcement, such as bars or mesh, to compensate for the loss of section due to corrosion.
3. Concrete repair: Perform repairs on the damaged concrete with proper techniques that include:
Being aware of the incipient anode effect.
4. Remove contaminated concrete.
5. Cleaning and corrosion removal all around the rebar, using appropriate techniques.
Apply corrosion-inhibiting products to the remaining rebar.
6. Apply corrosion inhibitors to the remaining concrete.
7. Apply repair mortar or structural resins.

To select and apply the most appropriate products, the expertise of professionals comes into play, avoiding unsuccessful repairs that lead to costly recurrences for owners [16].



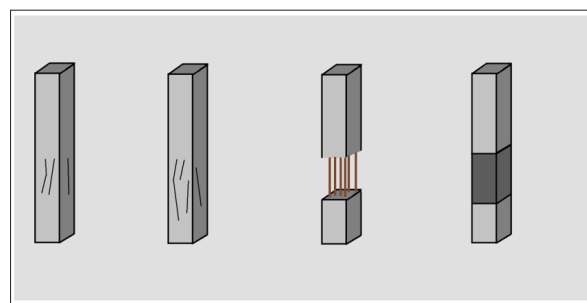
Image 7: Shows the process of corrosion column reinforced concrete repair [17,18].

This problem is addressed by removing concrete from foundation columns to replace the rusted steel with new reinforcing steel in the process of treating iron rust in concrete or welding pieces of new reinforced steel onto those exposed to rust, starting by removing the concrete from foundation columns to replace rusty steel with new reinforcement steel in the process of treating steel rust in concrete. The mistake that they make during these procedures of maintenance, working on many columns at the same time, where separating concrete from many columns of the building causes unbalance in the structure and leads the building to fail. The illustration (5) shows what often happens during the maintenance of buildings, where the concrete is removed from the columns for welding still pieces onto the rusted parts, where concrete is removed from a large number of columns for a long period until the worker completes the welding process for all the columns, and then the cement mixture is added to the zones that were worked on. At this time, the building is exposed to the risk of uneven distribution of weights, which leads to the building falling during maintenance.



The illustration (5) shows the mistake that they make during the maintenance of working on many columns at the same time, where the concrete is removed from the columns for welding still pieces onto the rusted parts, where concrete is removed from a large number of columns for a long period, the building is exposed to the risk of uneven distribution of weights, which leads to the building falling during maintenance.

If this method is the preferred method for restoration for economic reasons, preliminary calculations should be carried out before work begins to check the distribution of weights, where it's preferred to work on a small number of columns or (one by one) as shown in the illustration (6) to prevent any risk of uneven distribution of weights and avoid any incident of buildings collapsing during the maintenance.



The illustration (6) shows the correct way of maintenance and working on columns one by one, to prevent the imbalance in the structure due to the heterogeneous distribution of the building weight on the remaining columns.

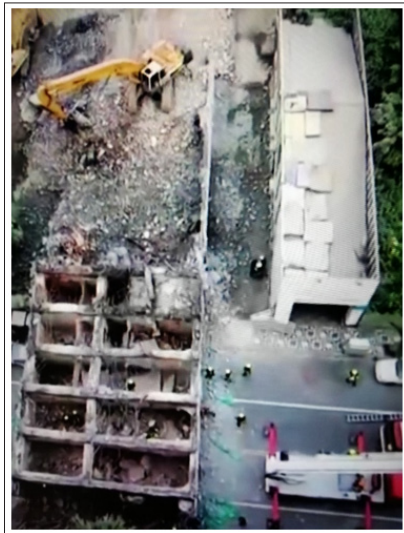


Image 8: Shows a collapsed building during maintenance due to remove several concrete columns.

Preventive Standards during Maintenance: include regular inspections, corrosion protection for reinforcing elements, and timely repairs to address any identified issues. Building maintenance is essential to ensure the safety and longevity of structures, and identifying and addressing potential problems early on can prevent catastrophic failures. The collapse of the building may have occurred during the poorly studied maintenance procedures when the concrete was removed from the most important columns of the building, for welding pieces of iron to be added or replaced instead of the iron that had corroded due to rust. Where buildings fall due to the absence of the most important supporting columns, the procedures of the maintenance and restoration operations should be achieved carefully with complete studies and the provision of temporary supports to the building instead of the supporting columns that are under maintenance during restoration. It is also possible that the erosion of the building grounds occurs due to the high loads of the buildings compared to the nature of the land, which is also changeable according to climatic changes, such as an increase in the rate of moisture in the soil during floods.

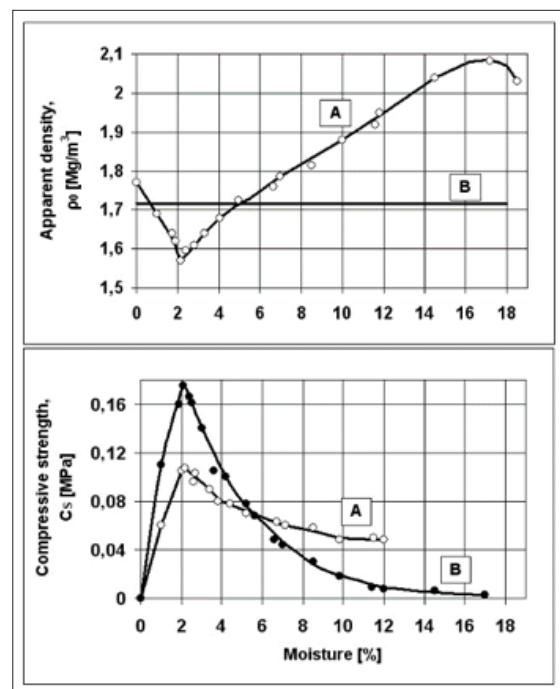


Image 9: Shows collapsed building during the flooding, where the humidity increases in the ground.

Moisture or Psychrometry

This engineering term to describe matters relating to the determination of the physical and thermodynamic properties of gas vapour mixtures, where the mass of water vapour per unit volume of air containing water vapour, this quantity is also known as the density of water vapour, it is the same as the specific enthalpy of a pure substance vapour per kilogram of dry air, compaction of soil and increase the pressure on the soil to the volume, these procedures achieved in the first steps to start building to improve the physics characteristics of the soil and make the ground able to carry the loads of the building to reduces the chances of slope stability problems such as landslides, compaction of soil results a lower void ratio the water tends to keep the soil particles separate without causing an appreciable decrease in the air spaces.

The dry density (Y_d) may calculate via the following equation:
 $Y_d = Y / (1 + M) \dots\dots 2$
 $M =$ is the water content



The illustration (7) influence of moisture on compressive strength of a green sand [19].

Molecules of water adsorbed into inter-packet spaces of the clay help create layers of monomolecular water and swelling of the bentonite molecule-water set, which makes the distance between the clay packets increase more than two times (from 0.94 to 2.1 nm). The basis for formulation of this hypothesis are observations of sensitivity of mechanical properties of sands, as presented in the illustration (7) therefore the decrease or increase in the percentage of moisture in the soil of the ground due to drought or flooding is as a result of the decrease in rainfall rates for many years, which leads to a change in the physical properties of the soil towards the low properties so that it will no longer able to carry the high weights of these buildings any more, and this effect of global warming threatens the safety of buildings and has a serious impact upon the economic development and social stability, therefore it's necessary to consider this factor in designs of building to reduce the effects of the heat upon the building such use the heat

insulators and heat dissipation to protect buildings of the extreme heat of the sun ray especially in the summer.

The Effects of the Humidity on the Safety of Buildings

High humidity levels can cause extensive damage to buildings and create an unhealthy environment for occupants. According to the Environmental Protection Agency (EPA), too much moisture in a building can cause significant damage, including:

1. Corrosion of building components, including structural fasteners, wiring, metal roofing, flooring adhesives, and roofing adhesives.
2. Water-soluble building materials return to solution.
3. Warping, swelling, or rotting of wooden materials.
4. Damage to brick or concrete during freeze-thaw cycles and by subsurface salt deposition.
5. Damage to paint and varnish.
6. Reduction of thermal insulation insulating value (R-value).
7. Mold, bacteria, wood-decaying molds, and insect pests like termites and carpenter ants.

A building's air humidity level can play a huge role in the transmission of airborne viruses and droplets. The purpose of humidity control in buildings: Humidity control helps extend the life of buildings and keeps employees within facilities healthier and more comfortable. Controlling the moisture and dryness levels in a facility can fight off mold and corrosion and protect inhabitants from adverse health effects. One of the most effective ways to reduce humidity and control the moisture content in your building is to install cost-effective high-volume, low-speed fans in the facility. In the meantime, the fans also produce better air quality and make a more comfortable environment for the inhabitants, increasing productivity and helping to maintain the indoor air quality in the building when paired with proper ventilation practices. If you keep the windows and doors open in your facility, HVLS fans are able to circulate the clean outdoor air throughout your facility and eliminate stagnant, unhealthy indoor air. HVLS fans also mix warmer ceiling air with cooler floor air, which increases the evaporation rate, thus reducing moisture in your building. You can use fans with a dehumidifier to reduce humidity and condensation even further. [20] When the building has a high humidity level for a long period of time, the excess moisture can wreak havoc on a building's foundation. One potential issue is excessive moisture in the soil surrounding a building, which can lead to soil expanding and exerting excess pressure on the foundation walls. Over a period of time, this pressure can cause cracks to form, leading to structural integrity problems that can be very costly to repair. Also, when the foundation has prolonged exposure to moisture, concrete or masonry tends to weaken, making it more susceptible to erosion and degradation. High humidity can do damage to the building's structure: The effect of the metallic corrosion of the metal components, such as support beams or reinforcements, is prone to corrosion in humid environments, leading to structural weakening. Other metal components in the home, like doorknobs and hinges, can rust and become harder to use. A solution may be adding dehumidifiers to the building, which can play a crucial role in preserving the longevity of homes and businesses. Humidity doesn't discriminate when it comes to building materials. Besides concrete, materials such as wood, metal, and drywall can all be damaged with prolonged exposure to high humidity levels. Homes and businesses that are primarily made from wood are particularly at risk, as moisture tends to cause the wood to swell, warp, or rot. Metal components, such as support beams or reinforcements, are prone to corrosion in humid environments, leading to structural

weakening. Other metal components in the home, like doorknobs and hinges, can rust and become harder to use. Most drywall is not made to withstand high levels of moisture. One example of how high humidity may pose a hazard for a building is the case of a warehouse with poor ventilation and no humidity control, where wooden beams are constantly exposed to high humidity levels. Over time, the moisture that is absorbed into the wood can start to swell, warp, or decay. When wood deteriorates, its load-bearing capacity is compromised, posing a safety hazard to the entire building. This degradation of wooden beams can increase the risk of collapses or structural failures, especially under adverse weather conditions. [21]

The impact of fires on the safety of buildings: Fires have a serious impact on the safety of buildings for two reasons

1. The high temperatures of fires accelerate water to escape from concrete more quickly, turning concrete into a brittle, crumbly material devoid of any mechanical resistance.
2. The occurrence of fires in a specific location in the building leads to heating of that area and expansion materials of the walls and rest parts, which leads to creating cracks in the interstitial zone with the nearby locations where there is no heating or expansion.
3. The effect of the difference in the rate of expansion of reinforcing steel compared to the rate of expansion of concrete increases at high temperatures. As the steel expands at high rates in concrete, this leads to the creation of cracks in the concrete. The danger of fires to buildings increases as much as fires are larger and also as long as the duration of fires lasts, as the area affected by the heat expands to wider zones and the zones of creation and growth of cracks in the building expand to wider zones. These mentioned factors lead to a reduction in the building's lifespan and expose the building to the risk of collapse before the end of its theoretically specified lifespan. Here, automatic fire extinguishing systems [22] should be included in building designs so that fires can be extinguished quickly and automatically via this developed equipment whenever they occur, before expanding their effects and threatening the safety of the building.

The Underground Nuclear Tests [23]: This factor causes tremors in the ground is the violent vibrations caused by the underground nuclear explosion tests in some countries that aim to obtain new data on nuclear engineering sciences, nuclear explosions stimulate the speed of landslides, especially in areas that are already suffering of the effects of drought and loss of large rates of water because vibrations of nuclear explosions move the sand to the state of more dense forms, and this will generate deep gaps in the material which lies underneath of the surface threatening the surface of the ground with dangerous collapses because the dry sand underground needs a required energy to stimulate their movement where these vibrations of the nuclear explosions are sufficient to activate the movement of the dry sand.

Conclusion

Buildings possess a defined lifespan attributed to the chemical properties of concrete, which release water molecules that result in a reduction of volume and the formation of cracks. These reductions occur as water molecules are gradually released, leading to cracks in concrete structures. When designing a building, it is essential to consider factors such as global warming and intense solar radiation, while avoiding designs that incorporate outward extensions. This approach helps to mitigate varying exposure rates to sunlight and different expansion zones, thereby preventing discrepancies in expansion between the interior and exterior

areas of the same concrete layer, which can lead to cracks in the interstitial zone. It is crucial to prevent the formation of cracks in this zone, as they may ultimately result in structural failure. The expansion differences between the outer and inner surfaces are most pronounced due to the outer surfaces being subjected to direct sunlight, while the inner surfaces are cooled by air conditioning. This disparity can create tension and potentially result in cracks within the concrete materials, leading to stresses and strains in the overall structure. Consequently, minimise exposure to heat sources by implementing heat insulation, particularly in exterior areas frequently subjected to sunlight. Consider thermal insulation as a fundamental component of the structure to maintain a stable temperature and mitigate variations in heat expansion rates by selecting appropriate materials. Additionally, take into account the colours of the building during the design phase, as lighter shades reflect heat more effectively than darker ones. It is crucial to highlight the significance of material compatibility and design factors under fluctuating temperature conditions. Regular upkeep and restoration of buildings should be scheduled consistently by professionals, ensuring that preliminary calculations are conducted prior to commencing work to assess force distribution. Focus on a limited number of columns to avert the risk of uneven weight distribution and prevent potential incidents of structural failure during maintenance. A comprehensive analysis must be conducted prior to initiating any building maintenance activities, emphasizing the importance of executing work safely and correctly rather than hastily. It is crucial to provide temporary support during maintenance to maintain the stability of the building [24]. When it comes to the significance of colour in building design, lighter shades are more effective at reflecting heat compared to darker ones, highlighting the necessity for material compatibility and design that accommodates varying temperature conditions. Regular building maintenance and restoration should be systematically scheduled by professionals, ensuring that preliminary calculations are performed before commencing tasks to assess force distribution. It is advisable to work on a limited number of columns to mitigate the risk of uneven weight distribution and to prevent potential incidents of building collapse during maintenance. A comprehensive analysis should be conducted prior to initiating any building maintenance activities, emphasizing the importance of safe and proper work practices over the speed of completion. It is crucial to provide temporary support during maintenance to maintain the stability of the building. The occurrence of a building collapse does not solely indicate that the expansion rates between the external and internal components, as well as among the various materials within the building's structure, were at fault. Rather, the significant differences in expansion rates throughout the building's lifespan resulted in the development of severe structural cracks. The moment of collapse signifies the point at which the building accumulated the necessary kinetic energy—whether from an external or internal source—that caused the material of the building to transition from a state of semi-stability to complete stability after the potential energy within the material was released. This transformation leads to a reduction in energy content, as all materials in the universe inherently strive to release energy and shift towards lower energy content, higher atomic entropy, and a state of greater stability.

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