

REPAIR OF FIRE DAMAGED BUILDINGS

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During my 10 years inspecting and reporting on fire damaged buildings I have seen many different approaches to the problem of managing competing interests of the owner, the builder and the insurer. While there have been some spectacular successes in claims management there have also been many equally spectacular failures.

Fire is the most destructive of the different types of building damage and the most technically demanding for the Building Surveyor. Restoration costs are usually high and construction periods long so that the Insurer is exposed to greater costs and has to manage the claim over a longer period than in most other claims.

Building Consultancies generally appoint their local consultant to the claim without considering the technical complexity of the report, the need for specialist knowledge and the need for construction management and project management during reconstruction. Insurers appear reluctant to appoint a Project Manager.

When a Building Surveyor inspects and reports on fire damaged buildings he is concerned with the visible and invisible structural damage caused by fire, building regulation and planning laws which govern reconstruction and the interim safety of the damaged structure.

Fire may change the shape of the structure, the appearance of surfaces and the physical properties of material. On first view, no matter how many fires the Surveyor has attended, the appearance is catastrophic. Closer inspection will however usually reveal a much lesser extent of damage than initially anticipated. Experience is required to understand where damage has occurred and to what extent the building is damaged.

Damage is caused by heat and effluent. Structural damage may be caused by failure under load as the properties of materials changes either temporarily or permanently and/or as a result of failure caused by additional loads imposed due to the fire. Damage may be in remote areas.

Specialised knowledge is required regarding the nature of building materials, their behaviour when heated and cooled, the constituents of the effluent and heat produced and dissipated throughout the building. Knowledge of the prevailing atmospheric conditions is also of use.

When heated, materials undergo physicochemical changes in their properties accompanied by transformation in their microstructure which may be either temporary or permanent. When Concrete is considered as an example, at 500⁰C it is completely different to the material at room temperature. Radiant heat flux can be calculated to determine what temperatures may have been reached and tests are available to determine if concrete has been altered. If the material has been altered and if the damage is permanent and has an impact on the structure, redesign of the building may be necessary. To determine the importance of any changes to the structure reference to the original design may be necessary. When the inspection and repair process is properly managed a pre-determined level of damage will trigger referral by the Building Surveyor to the original designer.

The knowledge required to inspect and report on fire damaged buildings is not readily available. Courses are not offered where the appropriate information is conveyed to Students, Engineers and Architects do not receive instruction on damage caused by fire. Research relating to material damage caused by fire is directed toward

fire protection and safety, rehabilitation after fire is not considered.

Research based information which can be applied to repair of fire damaged buildings is coincidental to the purpose of research into the ability of materials to withstand heat. There is a positive in that information not generally available to fire safety designers is readily available after the fire and is site specific. The knowledgeable and experienced Surveyor can combine scientific data and physical evidence to fairly accurately determine damage which has occurred throughout the building.

Data relating to the mechanical properties of solids used in structures is usually derived from conventional tensile or compressive tests. The information relating to properties of materials is valuable and can be applied along with calculation of radiant heat flux to estimating if damage may have occurred. When it is apparent from the calculations that material may have been damaged tests can be carried out to confirm or rebuff the occurrence. Testing will determine if structures can be saved or what alteration or renewal is required. Project Management is necessary along with the Inspection and Testing procedure to efficiently rehabilitate the building.

Tests have been developed to determine the nature and extent of damage caused to concrete and steel. Testing should be carried out when calculation indicates temperatures have reached pre-determined levels.

Some examples of the more common damage to material which must be considered is:

STEEL

The thermal expansion of steel (about $11.4 \times 10^{-6} \text{ mm}^{-1} \text{ K}^{-1}$.) must be considered along with a substantial contraction at the conversion from the ferrite-pearlite structure to austenite.

In fire safety design the critical temperature of steel structural members may be calculated using algebraic equations. Different approaches are taken to design in different areas of the globe and

amongst other things they consider regional differences in construction practice, steel type and climatic conditions.

The European Convention for Constructional Steelwork provides a guide to the maximum allowable reduction in yield strength by considering the applied loading, beam geometry, structural end conditions and whether the applied loading results in stresses in the elastic or plastic range. Critical temperatures range from 510°C to 650°C .

The Literature contains data to suggest a critical temperature for slender axially loaded columns of 505°C at which elastic buckling will commence for columns under the maximum permissible stress.

Few structures are under maximum permissible stress so buckling will commence at higher temperatures in most instances however at 600°C . steel has lost about 60% of its strength. It is reasonable to assume that buckling will have commenced somewhere between 500°C and 600°C , well below the conversion temperature.

Many buildings where the structural steel is apparently undamaged have been demolished because "the steel properties have been changed by the heat in the fire". The conversion temperature for eutectic steel is 724°C so it can be seen that the structure will deflect at temperatures well below that at which its properties are altered. This may not hold true for specialist steels.

Where deflection in steel members is visible replacement is generally the most economically viable method of repair. In this instance if replacement is to match existing, revised structural design is not required. There are instances where distorted steel has been retained in rehabilitated structures in the United States where steel framed bridges have been retained after the altered steel properties were proved to be adequate.

Tests are available which can be performed on site to identify changes which may have occurred in steel. Should Insurers or owners be presented with a recommendation to demolish a fire

damaged building they may be wise to request justification for that recommendation.

MASONRY

Coefficient of thermal expansion for clay bricks is about $5.5 \times 10^{-6} \text{ mm}^{-1} \text{ K}^{-1}$. The structural properties of bricks is not of great importance in building design because they are rarely used as structural elements. Damage caused by expansion and contraction in masonry is often not immediately obvious following fire however when temperatures reached have been calculated and those temperatures were sufficient to cause expansion beyond the capacity of the structure to accommodate, detailed attention can be directed to the appropriate areas.

PLASTER PRODUCTS

Consideration of the properties of Gypsum which is used in many forms in buildings is of particular importance in assessing the damage. It is essential that the temperature reached at the Gypsum surface is known so that the extent and nature of damage can be determined.

SURFACES

Tests have been developed to determine if porous material has been affected by products of combustion. The Building Surveyor will test surfaces when heat is calculated to have reached a pre-determined level.

It is important to know when and if it is safe for residents to remain in a fire damaged building and if out gassing may occur any time after the fire. Surfaces are damaged by the effects of effluent and exposure to radiant heat flux. The nature of the effluent changes with distance from the fire as it cools and loses the energy required to maintain buoyancy in the flume.

Misinformation regarding the nature of damage to material will result in the use of inappropriate cleaning methods which may not achieve the required result or may not be required at all. Some procedure may be a health risk. The cleaning procedure must be managed.

Temperatures in building fires can be calculated when the fuel load and compartment properties are known. This calculation combined with empirical evidence provides a good indication of heats reached in different parts of the structure. When the temperatures are known, the form of damage to the structure and fabric can be understood so that site inspection and reports are able to accurately schedule all damage either visible or invisible.

The inspection, testing and repair process for steel structures, timber structures, masonry structures and reinforced concrete structures are all different. A management process is available that will ensure pre-determined and appropriate action is taken at each stage and that over or under servicing does not occur. The process is documented and transparent.

We have developed a comprehensive system of inspecting, testing and reporting damage to buildings involved in fire and for management of the repair. Please contact Paul McNamara. © Paul McNamara 2010.