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AN OVERVIEW ON FIREFIGHTING PROBLEMS IN REINFORCED CONCRETE BUILDINGS

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Abstract- Fire is the most common hazard which may cause damage of structures along with loss of lives of occupants. It cause reduction of reinforced concrete structure strength, weakness of steel and concrete bond and change in color of concrete. During a fire event, firefighting is the initial step to prevent huge damage that involves numerous difficulties and complications e.g. obstacles in timely response and firefighting resources. The purpose of the study is to analyze the firefighting problems faced by firefighters. This paper provides an overview on the challenges of firefighting in reinforced concrete buildings and their remedial measures. The damages due to fire, preparedness of firefighting and firefighting barriers are discussed by a brief study of state of the art. The outcomes provide fathom to firefighting and possible solutions.

Keywords- Firefighting problems, RC buildings firefighting, Fire damages.

1 Introduction

Fire is hazard and the most potential risk for structures. Specific guidelines are provided by international codes to counter this hazard for design of structures [1]. These guidelines provide a supervision to develop safety evacuation plans, establish fire safety drills and special training to staff for quick response. Reinforced concrete buildings are good in strength and structural accomplishment under a fire event caused by any sudden flame or ignition by any combustible material [2]. In written any such incident has not been noticed in which RC building completely collapse down. RC buildings experienced cracks on plaster and damage is countered by suitable repairing [3]. The type of repairing depends upon the situation of cracks and loss of strength measured by appropriate methods. The external and internal ignitions are the two main causes of fire. Internal fire can spread outside by means of windows and doors and can damage the exterior covering of building. The burned material placed outside of building generates cause of damages to the nearby parking vehicles and other small buildings if the fire affected building is bigger in height than the others.

Firefighting is an important initial element to keep the occupants safe and to reduce damage rate. Therefore, firefighting and emergency hazard response is a major issue in developing countries. Fire brigade play a vital role in fire extinguishing of buildings. RC high rise buildings have multiple stories, an extra effort is required to reach up to the fire affected area for fire extinguish purpose [4]. The response time increase with the increase of height of building and increase in distance that has to be travelled by firefighters. The fire department emergency response depends upon the availability. It means that to which extent resources are ready to respond. Capacity is the potential of resources to handle hazard and operational. Effectiveness; the capacity to coordinate assets sent to the dangers to which they are reacting. The protestation of life governs the importance of protecting property. Safety in terms of protection of property and efficiency are three main goals of firefighting. When safety is at stake, property can be sacrificed. Here Property to be considered is fire department property i.e. fire engine, fire house and tools. These asserts must be protected if there is no risk to safety [5].

The assessment of fire risk approach is used in buildings to assess the fire hazard safety level present in buildings. These approaches use probabilistic and statistical method by fault or event trees, ranking of fire risk method and multi criteria

evaluation based stochastic computer simulation [6]. The fire can cause huge damage to property and lives of residents, if not deal with attention. The preparation for the firefighting is essential to extinguish fire before allowing to spreading and being out of control. Fire safety drills are important for trained specific staff to know how to respond if fire happens and spread suddenly. Firefighting includes problems related with response time. It is the time to reach the fire affected area. Type of access to active fire area matters a lot. The capacity of liquid/gas fire extinguishers and their usage techniques, petrochemical fire extinguish, presence of appropriate fire extinguish system and equipment i.e. smoke detectors, fire alarms, sprinkler system and alternate routes provided for safe evacuation [7]. The aim of the study is to analyze the problems/challenges faced by firefighters during firefighting in RC buildings. The appropriate provisions and preparation for fire firefighting are briefly dicusscud to provide possible solutions for the challenges of firefighting.

2 Damages due to fire in RC structures

When exposed to fire, concrete can suffer huge damage but concrete is poor conductor of heat. Reinforced concrete structures when exposed to raised temperatures due to fire go through a significant change in material properties i.e. compressive strength, cracks in plaster and concrete cover, spalling of concrete loss of steel and concrete bond strengthening and its destruction may occur. [8].The cracks appeared on surface depends upon the intensity of damage of RC member. Due to this elevated temperature concrete structures may collapse down, although complete collapse of structure under fire has not been recorded yet. The damage of structure depends upon the type of fire, nature of combustible material present i.e. change in stress and strain ongoing stage and after fire. It also depends upon the fire resistivity of concrete structure because different types of concrete composites have different fire resistance [9]. The loss of human lives during fire living in RC buildings depends upon the occupancy rate, the average of people spend 90 % of their time in indoor [10].

The composites of cement show different behavior when exposed to fire, depends upon the type of material use in these composites [11].The RC structures which are taken as excellent performance structures may have impact of prevalent execution in fire and larger burn time [12]. As burn time increases the deformations of RC structure elements increases. The fire incidents in petrochemical areas have caused huge economical loss by damage of RC structures and causalities. During fire event in petrochemical areas, life of firefighters is at risk [13]. Fire damaged concrete assessment is done by visual inspection that involves spalling, cracking and color change. Guidance of temperature is provided by change in color. The color of spalling surface is different from original one. Quartz or chert aggregate particles cause cracking popouts, dehydration and spalling provides indications of temperature to which extent concrete was exposed as described in Fig 1. By heating at temperature of 300 °C or above this temperature, the normal concrete's color changed to pink (300-600 °C) after this converted to whitish gray (600-900 °C) and at peak temperature it lead to buff (900-1000 °C) [14].

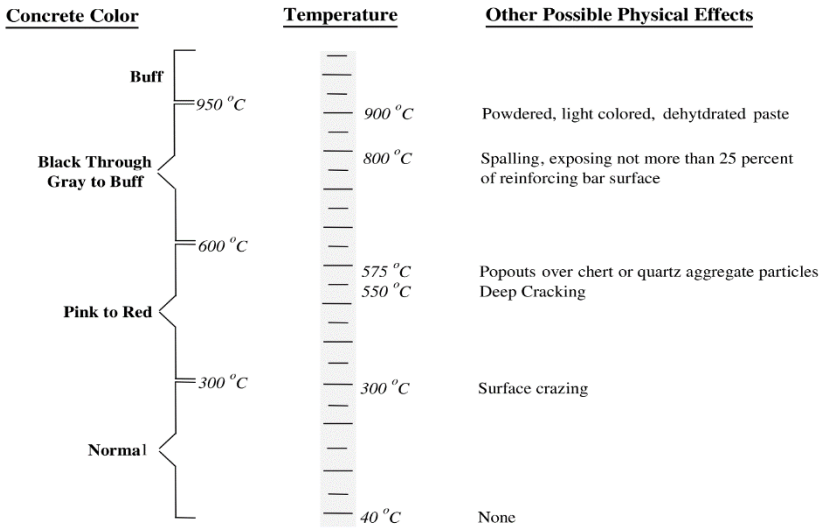

Figure 1: Change in colour of concrete by increase in temperature [14]

3 Preparedness of firefighting

A fire safety framework is an anticipation and concealment method received in the planning of a structure. Generally active and passive systems are adopted as fire protection systems. By utilizing equipment that work manually or automatically the active fire protection system is executed. It is applied by the persons present during fire event taking part in extinguishing operations. This method is used for taking early fire countermeasures, including, automatic sprinklers, emergency lighting, emergency communication equipment, upright pipe systems and hoses, fire lifts, fire alarms, smoke detectors, fire doors [15]. Water mist system is used if water in huge quantity is not available or accessible in confined space and found effective [16]. Efficiency of sprinkler system depends upon the extinguishment of fire and delivery of water to fire by designed amount. Classification of sprinkler system according to hazard type, density of water discharge, head generated by this discharge and area covered is explained is given in Table 1.

Along with building classification some subsidiary parameters are set which are based on height of building, people effected and area characteristics to describe the appropriate use of fire protection system. Based upon the rules and regulations, building having height of 21, 23 or 30m should have sprinkler system. The buildings built in 750, 1000, 1200 or 1500 m^2 area may require fire hydrants or building of any build area with height of 12m [17]. Fire extinguishers are placed in buildings for immediate response against fire. Firefighting staff use these fire extinguishers as an initial response to prevent spreading of fire to whole building or area in which fire is present. Smoke detectors provide detection of any kind of smoke as a result of burning of any material or even by a cigarette as different type of smoke detectors have specific smoke detection sensitivity. Emergency stairs provide means of egress to occupants and alternative route for accessing firefighting staff if main route stairs side under fire [18].

Table 1-Sprinkler hazard and requirements [19]

Occupancy	Hazard	Density of discharge	Sprinkler Heads	Coverage
Shops/mall	Ordinary Hazard III	5 mm/Min. m^2 over 216 m^2	15mm orifice head	12 m^2 of area
Cinema	Ordinary Hazard III	5 mm/Min. m^2 over 216 m^2	15mm orifice head	12 m^2 of area
Car park	Ordinary Hazard II	5 mm/Min. m^2 over 144 m^2	15mm orifice head	12 m^2 of area
Plant rooms	Ordinary Hazard I	5 mm/Min. m^2 over 72 m^2	15mm orifice head	12 m^2 of area
Office	Light Hazard	6 sprinkler heads operating at a flow of 48 l/min	10mm orifice head	21 m^2 of area
Ceiling Space	Light Hazard	6 sprinkler heads operating at a flow of 48 l/min	10mm orifice head	21 m^2 of area

4 Issues during firefighting and their remedial

The analysis of high rise RC structures reveal that many aspects exists which cause issues during firefighting. Insufficient fire resistance of structure cause early collapse of structure that can be overcome by taking into count the fire safety measures while designing RC structures to maintain technical characteristics for a specified time period . Large internal volumes without specific separation of fire barrios should be prevented. The division of high-rise building into fire compartments used horizontally fire walls and use vertically fire ceilings. The minimum fire compartment should be 1500 sq.-m. The access to active fire area in high-rise RC building is a major issue because elevators are often de energized due to fire, rescue elevators with special equipment having minimum capacity of 1000 kg should be provided in building for easy access of firefighting staff to their relevant place during fire [20]. Hence fire hazard is directly related to the lives of persons present in fire effected building.

Immediate response to fire may lead to reduce the damage, unqualified staff cannot respond as per the requirement. This issue can be solved by arranging fire safety drills to minimize response time. Safe evacuation of occupants is desire of firefighting staff. Evacuation exits lead to the outside of building, output to the stair well, exit to fire proof containers present on technical floors [21]. Firefighters face toxic gases during firefighting in RC buildings present in petrochemical areas, the problem can be resolved by use of toxic gas detectors and appropriate dress if toxic gas is detected [22]. Firefighters carryout firefighting operation in near flash out or flash out conditions. Low visibility and high temperature in a house building fire can create a difficult firefighting situation. Substantial radiation towards firefighters and ignition of smoke can be started. Gas cooling technique can be used to reduce fire flashing and ignition of fire gases. A fog nozzle produce small droplets of bursted water. While passing through hot gases the evaporation phenomenon occurs by keeping water volume to minimum and create a safer environment [23].

5 Conclusion

By conducting this study following conclusions can be drawn:

- Significant decrease in strength occurs along with crakes on members of RC structure and change in color while expenciencing high temperatures due to fire.
- Early countermeasure should be taken, automatic fire sprinklers and other fire safety equipment should be installed to extinguish active fire.
- Fire hazard should be taken into count while designing RC structures to provide a good fire resistance.
- Barriers to firefighting; access to active fire area, response time, fire safety drills should be minimized to reduce number of causalities and economical loss

The above outcome is favorable indicating the cracks, spalling and color changes due damages of fire in RC structures. Appropriate preparedness is essential for quick response to fire. Firefighting problems can be reduce by applying provided solutions.

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