CHAPTER 6

SUMMARY AND CONCLUSIONS

An experimental investigation under short-term loading aimed to study the behaviour of reinforced concrete elements subjected to fire has been conducted. The experimental program consists of testing 30 RC beams and 30 RC columns. 15 RC beams were made of normal concrete mixes of w/c ratio 0.45, 0.5 and 0.6. The other 15 RC beams were made of high strength concrete mixes. In addition of 15 RC columns were made of normal concrete mixes of w/c ratio 0.45, 0.5 and 0.6. And 15 RC columns were made of high strength concrete mixes of s/c ratio 12.5%, 20% and 25%.. The tested concrete specimen is of 150 mm depth, 150 mm breadth, and 1600 mm height.

Based on this investigation, the following conclusions can be drawn:

1- The presented fire technique proved to be easy to develop, practical to use and inexpensive.

2- Normal strength Concrete beams exposed to fire only exhibited the lowest value of ultimate load by about 15% if it is compared to the other beams exposed to load and fire.

3- Normal strength Concrete beams were loaded firstly by 60% of their ultimate load. Then, the beams were fired up to 600^{o}c before cooling and crushing them, the ultimate load was decreased by about 26%, 32%, and 25% for beams made with mixes M1, M2, and M3 respectively.

3- High strength Concrete beams exposed to fire only exhibited the lowest value of ultimate load by about 95% if it is compared to the other beams exposed to load and fire.

4- High strength Concrete beams were loaded firstly by 60% of their ultimate load. Then, the beams were fired up to 600^{o}c before cooling and crushing them, the ultimate load was decreased by about 90.7%,87.1%, and 68.2% for beams made with mixes M1, M2, and M3 respectively.

5- Using the anti-fire coating improves the ultimate load with respect to the uncoated beams.

6- The influence of coating high strength Concrete beams HSCB14, HSCB15, HSCB24, HSCB25, HSCB34, and HSCB35 with anti-fire coat. A significant increase was observed due to the use of the anti-fire coat. The ultimate load of beam HSCB14 was 34.97 KN and represented 1.089 and 1.202 with respect the ultimate load of beams HSCB11 and NSCB13 respectively. Similarly the ultimate load of beam HSCB24 was 34.13 KN and represented 0.966 and 1.109 of the ultimate load of beam HSCB21 and HSCB23 respectively. For beam HSCB34, the ultimate load was 29.1 KN and represented 0.732 and 1.073 of the ultimate load of beams HSCB31 and HSCB33 respectively.

7- The gradual cooling in air in the case of the flexural elements exposed to fire may not provide the best results. This should be attributed to the propagation of the cracks while the beam is still loaded. However, more research work to investigate the effect of cooling methods is needed.

8- The influence of cooling methods on the ultimate load of the tested normal strength Concrete beams. The beam NSCB15 lost about 37.5% of its original ultimate. Also the beam NSCB14 lost about 25.5% of its original ultimate strength. Similar results were obtained for beams made with mixes M2 and M3. For beams NSCB23, NSCB24, and NSCB25 the loss of the ultimate load was about 13%, 28%, and 53% respectively. For beams NSCB33, NSCB34, and NSCB35, the loss of the ultimate load was 11%, 20.5%, and 43.5% respectively.

9- The influence of method of cooling on the ultimate load of the tested high strength Concrete beams. The ultimate load of the beam HSCB14 was 34.97 KN and represented 1.393 of that of the beam HSCB15.It showed be noted that beam HSCB14 was cooled with water while beam HSCB15 with kept cooling gradually in air till reaching the room temperature. Similar trend was obtained when comparing the ultimate loads of beams HSCB24 and HSCB25. As shown, the ultimate load of beam HSCB24 was 34.13 KN and represented 1.62 of that recorded for the beam HSCB25. The ultimate load of beam HSCB34 was 29.1 KN and represented 1.155 of the ultimate load recorded for beam HSCB35.

10- Normal strength Concrete columns exposed to fire only exhibited the lowest value of ultimate load by about 30% if it is compared to the other columns exposed to load and fire.

11- Normal strength Concrete columns were loaded firstly by 60% of their ultimate load. Then, the columns were fired up to 600^{o}c before cooling and crushing them, the ultimate load was decreased by about 35%, 10%, and 35% for columns made with mixes M1, M2, and M3 respectively.

12- The influence of loading the high strength concrete column HSCC13 before rising the temperature. The ultimate load of column HSCC13 was 121.014 KN which represented 85.35% of the reference column HSCC11 similar results were obtained for column HSCC23 and HSCC33. The ultimate load of columns HSCC23 and HSCC33 represented 97.57% and 80.00% if they are compared to ultimate load of the reference columns HSCC21 and HSCC31.

13- The influence of cooling methods on the ultimate load of the tested normal strength concrete columns. The column NSCC15 lost about 22.00% of its original ultimate. Also the column NSCC14 lost about 35% of its original ultimate strength. Similar results were obtained for columns made with mixes M2 and M3. For columns NSCC23, NSCC24, and NSCC25 the loss of the ultimate load was about 13.00%, 9.00%, and 6.00% respectively. For columns NSCC33, NSCC34, and NSCC35, the loss of the ultimate load was 5.00%, 35.00%, and 33.00% respectively.

For further research work, the following are recommended:

1- Studying the behaviour of the reinforced concrete beams and columns by changing the dimension of the tested concrete specimen.

2- Using another method of cooling and study its tested concrete specimen.

3- Improving the behaviour of high strength concrete to fire by using powder RMPP (Raw Material of Pottery Powder) which improves the physical and mechanical properties of concrete upon firing at temperatures as high as $700^{o}C$.