7 SUMMARY OF CONCLUSIONS

This research investigated a novel approach of improving the strength, mechanical and durability properties of concrete by using magnetized water in mixing different ingredients of concrete. Results presented herein provide a better understanding of the mechanism of Magnetic structured water in using mixing water very efficiently in hydration for improving properties of concrete. Based on the results reported in this research work and key findings during the experimental investigations, the following conclusions can be drawn:

7.1 INFLUENCE OF MAGNETIC FIELD ON WATER AND COMPRESSIVE STRENGTH OF CONCRETE

1. A novel method of production of MW inspired by magnetic therapy for producing MW as mixing water and curing water in concrete is proposed
2. Nano studies conducted on water which is exposed to magnetic field indicates that the magnetic field exposure on water brings about internal molecular changes in water and increases surface area of water in unit volume.
3. When water is exposed to different poles of the magnet. The Mixed pole water (i.e 50% of North pole water +50% of South pole water) is giving good results in compressive strength and Surface area of structured water compared to that of individual pole water.
4. The workability of mixed pole magnetic water concrete is slightly more compared to normal water concrete.
5. For usage of MW as mixing water in concrete, 24 hours of magnetic field exposure time to water is found to be optimum.

7.2 MECHANICAL PROPERTIES

1. The strength studies shows that MWC also behaves likes a NWC in strength development i.e., developing very high strengths at early ages and less strength at later ages.
2. It was observed that with the addition of MW the compressive strength of concrete showed very significant increase in early stages of hydration and at 28
days this increase is around 55.7% and at 360 the final increase in the compressive strength is around 51.8%. The increase in compressive strength attributes to the enhanced hydration process in MWC due to availability of more surface area of water for hydration process.

3. The split tensile strength increase is about 12.6% in MWC at 28 days and 365 days.

4. Similarly the flexural strength increase is about 21.5% at 28 days of curing, this further increased to 29.3% at 365 days in MWC.

5. The Impact resistance increased in case of MWC. The impact strength increase is nearly 45%. In impact test it is observed that there is a significant improvement in first crack strength and ultimate strength in MWC because of more hydration and dense micro structure of MWC increases the resilience and strain relieving capacity MWC. This resilient character provides the excellent impact resistance and dissipates dynamic loading better than normal concrete. The increase in number of blows up to failure for MWC indicates its high energy absorption capacity which in turn enhances the increased impact resistance.

6. From the observations made from stress-strain curves at all ages both concretes, the MWC mixes have shown improved stress values for the same strain levels compared to that of NWC. It can be observed from stress-strain curves the MWC is more elastic and ductile compared to that of NWC specimens.

7. Toughness or energy absorption capacity of MWC grade of M20 has shown an increase of 45% when compared to NWC.

**7.3 DURABILITY PROPERTIES**

1. Chloride permeability of MWC shows less permeability of chloride ions into concrete when compared to NWC due to voids being filled with more hydrated products. Magnetic water added concrete has shown between 85% to 90% higher resistance against the chloride movements as compared to the chloride movements in NWC.
2. Diffusion Coefficient (DC) of chloride ions decreases with the usage of magnetic water in mixing of concrete. The MWC presented a higher resistivity to the migration of chloride ions than the NWC.

3. Auto clam Water permeability test shows that MWC is less permeable than the NWC the reason is that the more hydration in MWC concrete has improved pore structure due to filling up of voids with more hydration products subsequently reduction in the porosity of the concrete which substantially reduces the permeability of the concrete. Water permeability reduces in NWC concrete by nearly 80% in comparison to NWC.

4. MW concrete samples gave the lower Autoclam sorptivity index values compared to NWC. This means that the time taken for the water to rise by capillary action in MWC is longer and thus proved that MWC is less porous compared to the NWC concrete. The sorptivity index decreases in MWC indicating the dense pore structure formed due to relatively more hydration.

5. Auto clam Air permeability index of MWC specimens is reduced by nearly 50 to 80% for M20 grade concrete as compared in controlled concrete specimens. The Air permeability property indirectly represent the volume of pores and their connectivity.

6. The compressive strength decreased as the freeze-thaw cycles are repeated, the loss of compressive strength after the action of freeze-thaw cycles is evident. This may be due to the fact that the use of MW in concrete will reduce the quantity of voids and water movement in and out of the specimen thus reducing the freezing pressures successfully and indicating better resistance to freezing and thawing.

7. Radiography test conducted on the concrete specimens with and without MW shows that the Pores/flaws are less in MW concrete specimens.

7.4 MICRO STRUCTURE STUDIES

1. BET studies indicated that the Pore/Volume ratio of MWC specimens are reduced by nearly 22% compared with the NWC specimen. Also the Specific surface area of the MWC samples increased compared to NWC samples indicating that more hydration occurred in MWC.
2. The structure of MWC sample appeared to be more dense compared with NWC at all ages when visualized under Scanning Electron Microscope (SEM). SEM analysis also indicated that the basic composition in both concretes is same.

3. Nano-characterization technique- X-ray diffraction (XRD) confirms that the size of each particle in MWC is large compared to that of NWC indicating that more hydration occurred in MWC.

4. Thermo gravimetric Analysis (TG) and Differential Thermal Analysis (DTA) confirms that structure of MWC sample is very strong compared to NWC. From Thermo gravimetric Analysis, it is observed that for the MWC specimens the weight loss is less (18%) while for NWC specimens significant weight loss is observed (33%) which interprets that structure of MWC is very strong compared with NWC.

5. Use of MW in curing of concrete:
   The compressive strength of NWC and MWC cubes cured in MW showed an increase at very early age and at later ages the increase in compressive strength was very less. This increase in compressive strength in concrete when MW is cured for curing of concrete is due to ingress of small sized MW clusters deep into the C-S-H structure which enhances the hydration process.

7.5 USE OF MAGNETIC SALT WATER IN MIXING

   It is observed that the use of Magnetized chlorine and sulphate water in concrete mixing increased the 28 days compressive strength of concrete cubes by 26.62% & 42.63% respectively compared to that of non magnetized salt water concretes. The reason for this increase is due to faster hydration reaction in MSWC (CL&S) compared to that of chloride and sulphate reaction in concrete which tries to decrease the strength of concrete.

7.6 USE OF MAGNETIC TREATED WASTE WATER IN MIXING

   Magnetized treated waste water(i.e., Primary, secondary and tertiary treated water) concrete specimens exhibited increase in the 28 days compressive strength compared to that of non magnetized treated waste water. Compared with normal
water concrete, the compressive strengths of magnetized primary treated waste water is increased by about 9.5%, magnetized secondary treated waste water is increased by about 14.5% and magnetized tertiary treated waste water is increased by about 16% at 28 days.

7.7 FUTURE RESEARCH PERSPECTIVES

On-going research in JNTUH concrete laboratory investigates the possibility to use of Magnetic water in practical civil engineering applications.

1. The same investigation of influence of magnetic water on workability, strength and durability properties of concrete can be studied by varying the magnetic field strength.
2. Methods and systems can be designed to produce magnetic water on large scale to use in in-situ concrete works.
3. The present investigation can be extended to make concrete of higher grades and different types of concrete.
4. Further Nano studies can be carried to examine the Nano structure of MWC.
5. Effects of treated magnetized waste water on durability of concrete can be carried out.
6. Effects of treated magnetized salt water on durability of concrete can be carried out.
7. Strength and durability of concrete can be studied by increasing the concentration of chlorides and sulphates in mixing water.
8. This new Magnetic water technology can be applied to cement bricks/blocks to reduce the amount of cement to be used in them by replacing with fly ash or any materials.