A STUDY ON ENHANCING CHARACTERISTICS OF CONCRETE USING ANN MODELLING

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Abstract: In this study, researchers investigated the combined influence of two specific materials - flaky aggregates and steel slag - on concrete behaviour. Flaky aggregates refer to particles that are flat or elongated, which can negatively affect the compactness and mechanical properties of concrete. Steel slag, on the other hand, is a byproduct of steel manufacturing that can be used as a partial replacement for coarse aggregate in concrete, offering potential benefits such as increased strength. Given properties of the ingredients used in order to perform construction will effect prepared concrete. When it comes to preparing concrete for construction work, coarse and fine aggregates are the basic ingredients that go into cement concrete. Based on experimentation, several previous researchers resulted the conclusion that the type of fractured cooperating coarse or fine aggregate had a significant influence on both workability and strength of concrete.

In the current study, the synergistic impact of flaky aggregates and steel slag as a partial substitute for coarse aggregate on the performance of concrete, utilizing marble powder in place of sand, has been examined.

Artificial neural network has been used to develop a model for evaluating compressive strength of concrete prepared using above waste materials. Flaky aggregate and steel slag have been mixed in 10%, 15%, 20%, 25% and 30% of coarse aggregate in the concrete.

Increasing proportion of flaky aggregate has the negative effect on strength and workability and increasing steel slag results in enhancement of concrete strength whereas reduction in workability. M30 mix was used here and mixing both the materials together increases the early strength of concrete and low percentage increase of strength which gives the concrete with low workability.

Utilizing advanced modeling techniques, this study explores the effects of various types of aggregates on concrete strength, workability, and durability. Through extensive experimentation and analysis, the interplay between aggregate properties, such as shape, size, and mineral composition, and concrete performance parameters is elucidated.

Keywords: **[1.] Adom-Asamoah M, Afrifa R O "Investigation On The Flexural Behaviour Of Reinforced Concrete Beams Using Phyllite Aggregates From Mining Waste" Materials & Design, 32(10), 5132- 5140 [2.] Agrawal P., Gupta Y.P., Bal S. "Effect Of Fineness Of Sand On The Cost And Properties Of Concrete" Nbmcw October 2007 [3.] Akbulut, H., & Gürer, C. (2007). Use of aggregates produced from marble quarry waste in asphalt pavements. Building and Environment, 42(5), 1921-1930. [4.] Altaf et al. (2013) "Suitability Of Waste Glass Powder As A Partial Replacement Of Cement In Fibre Reinforced Concrete" Project Report, A.I.A.R. KALSEKAR POLYTECHNIC New Panvel 410 206, Navi Mumbai. [5.] Bant Singh, Dr, and Srijit Biswas. "Upgrading Properties of Aggregates in Flexible Pavements with e-Control."International Journal of Scientific & Engineering Research, Volume 4, Issue 9, September-2013 2543 ISSN 2229-5518 [6.] Chen J., Lin K.Y., Chang M.K. "Influence Of Coarse Aggregate Shape On The Strength Of Asphalt Concrete Mixtures" Journal Of The Eastern Asia Society For Transportation Studies, Vol. 6, Pp. 1062 - 1075, 2005 [7.] Hamzah M O, Puzi M A A, Azizli K A M " Properties Of Geometrically Cubical Aggregates And Its Mixture Design" Ijrras 3 (3) ● June 2010 [8.] Jain A K, Chouhan J S (2011) "Effect of Shape of**

Aggregate on compressive strength And Permeability Properties of Pervious Concrete" International Journal of Advanced Engineering Research and Studies E-ISSN2249 – 8974 [9.] Jarkasi, Mohd. Daud (2013) Influence Of Aggregate Flakiness On Marshall Properties For Asphaltic Concrete (Ac14) Mixture. M. Tech. thesis, Universiti Teknologi Malaysia, Faculty Of Civil Engineering. [10.] Kandekar S B, Mehetre A J, Auti V A "Strength Of Concrete Containing Different Types Of Fine Aggregate" International Journal Of Scientific & Engineering Research Volume 3, Issue 9, September-2012 [11.] Kaplan M F "The Effects Of The Properties Of Coarse Aggregates On The Workability Of Concrete" Magazine Of Concrete Research, Volume 10, Issue 29, 01 August 1958 , Pages 63 –74 [12.] Khatib J.M., Negim E.M., Sohl H.S., ChilesheN. "Glass Powder Utilisation in Concrete Production" European Journal of Applied Sciences 4 (4): 173-176, 2012. [13.] M. N. Bajad, C. D. Modhera, A. K. Desai "Resistance of Concrete Containing Waste Glass Powder against MgSO4 Attack" NMBCW MAY 2012 [14.] Meena Ankur and Singh Randheer (2012) "Comparative Study of Waste Glass Powder as Pozzolanic Material in Concrete" B. Tech thesis, NIT Rourkela. [15.] Muhit, I. B., S. Haque, And Md. Rabiul Alam. "Influence Of Crushed Coarse Aggregates On Properties Of Concrete." American Journal Of Civil Engineering And Architecture 1, No. 5 (2013): 103-106. [16.] Patil D.M., Sangle KK. "Experimental Investigation of Waste Glass Powder as Partial Replacement of Cement in Concrete" International Journal of Advanced Technology in Civil Engineering, ISSN: 2231 –5721, Volume-2, Issue-1, 2013. [17.] Polat, Rýza, et al. "The correlation between aggregate shape and compressive strength of concrete: digital image processing approach."International Journal of Structural and Civil Engineering Research (2013): 1-19. [18.] Ponnada M R (2014) "Combined Effect Of Flaky And Elongated Aggregates On Strength And Workability Of Concrete" Int. J. Of Structural Engineering, 2014 Vol.5, No.4, Pp.314 – 325 [19.] Saikia, N., & de Brito, J. (2012). Use of plastic waste as aggregate in cement mortar and concrete preparation: A review. Construction and Building Materials, 34, 385-401. [20.] Shayan and Xu (2006) "Performance of glass powder as a pozzolanic material in concrete: A field trial on concrete slabs" Cement and Concrete Research 36 (2006) 457–468. [21.] Shetty, M.S. (2003 Edition) Concrete Technology: Theory And Practice, S. Chand & Company Ltd, India. [22.] Siswosoebrotho B I, Soedirdjo T L, Ginting K "Workability And Resilient Modulus Of Asphalt Concrete Mixtures Containing Flaky Ggregates Shape" Journal Of The Eastern Asia Society For Transportation Studies, Vol. 6, Pp. 1302 - 1312, 2005 [23.] Taha B., Nounu G. "Utilizing waste recycled glass as sand/cement replacement in concrete" J. Mat. Civil. Engg., 21(12), 709-721. [24.] Tan K.W., Du H. "Use of waste glass as sand in mortar: part I- fresh, mechanical and durability properties". Cem. Conc. Comp., 35, 109-117. [25.] Vasudevan G., Pillat SGK (2013) "Performance of Using Waste Glass Powder In Concrete As Replacement Of Cement" American Journal of Engineering Research, Volume -02, Issue-12, pp- 175-181. [26.] Vyawahare M R, Modani P O "Improvement In Workability And Strength Of Concrete With Flaky And Elongated Aggregates" 34thconference On Our World In Concrete & Structures: 16 - 18 August 2009, Singapore [27.] Westerholm, M., Lagerblad, B., Silfwerbrand, J., & Forssberg, E. (2008). Influence of fine aggregate characteristics on the rheological properties of mortars. Cement and Concrete Composites, 30(4), 274-282. [28.] Zega, C. J., Villagran-Zaccardi, Y. A., & Di Maio, A. A. (2010). Effect of natural coarse aggregate type on the physical and mechanical properties of recycled coarse aggregates. Materials and Structures,43(1-2),195-202.

CHAPTER 1 INTRODUCTION

1.1 Background

Cement, fine and coarse particles, and water are combined to create concrete. Its adaptability—which allows it to be made to withstand harsh environments while still taking on the most inspiring forms—is what makes it successful. With the aid of innovative admixtures and diverse waste alternative materials (WAMs), scientists and engineers are working to further push its boundaries.
In the past, WAMs were made of easily accessible natural materials like volcanic ash or diatomaceous earth. Preferred over angular aggregates in terms of cement demand economy for a given weight-to-cement ratio are rounded aggregates. The workability, cement requirement, strength, and durability of concrete are all negatively impacted by flat particles in the mixture. Low-quality concrete was often generated by a high content of flaky aggregates.

The size of aggregates and material used instead of coarse and fine aggregates play a critical role in determining key characteristics of concrete, such as strength and workability. In addition to aggregate shape, the texture of coarse aggregates is also a significant factor. Some researchers argue against using rounded aggregates because they may affect the bonding between aggregates and cement. Moreover, the angular aggregates are better to rounded aggregates in the two circumstances –

1. Angular aggregates show evidence of a better interlocking achievement in concrete, which property makes it advanced in concrete used for road and pavements.

2. The entire surface area of rough angular aggregate is more than smooth roundedaggregates for the given quantity. Hence, due to greater surface area, the angularaggregates revealed higher bond strength than rounded aggregates.

Many researches and experiment had been shown that this adhesion or bonding between cement paste and the aggregate is influenced by a number of complex factor beside the physical and engineering properties. Higher amounts of surface smoothness will lead to a lower contact area, so that even a highly polished feature is relatively far from bond area as compared to an unpolished one containing the same diegetic volume.

Aggregate is one of the most important constituents used in concrete, as a large amount of properties and workabilities of concrete are directly affected by the properties of aggregates. Aggregates were earlier viewed as inert when measured chemically, also detained collectively by cement into a dense body about concrete. Nonetheless, the latest details prove that aggregates represent.

Nearly all of the concrete's mechanical and physical characteristics are dependent on the guaranteed characteristics of the aggregates, such as the aggregates' origin, their normal or heavy nature, and their dimensions, size, and geometry.

Fig 1.1 – Aggregates (Fine and Coarse)

Aggregates can be categorized as natural or artificial depending on their origins. Natural aggregates were quarried by shaping the crushed stones or from the water sources sides such as river or ocean. While synthetic aggregates can be acquired from byproducts of blastfurnace like industries.

Several codes of practices worldwide categorized course aggregates in several categoriesaccording to their geometry and dimensions such as rounded, irregular, angular etc.

Aggregates used for special purposes have been assembled into single class which is equi-dimensional or cuboidal. Now the flaky and elongated or identical size is investigated as the ratio of the smaller and longer dimension.

1.1.1 Parameters considered in present research

In the present research influence of following parameters has been determined to study the effect of aggregate type on the performance of concrete –

1.1.1.1 Workability of concrete

Workability of concrete determined has been related to the condition and

1.1.1.2 Compressive strength

The compression test can be used for determining the strength of plain, reinforced and pre- stressed concrete whether it is precast or cast in-situ. The main objects of the compression test is to investigate -

• The opposition to the compressive force

The concrete's homogeneity.
• The existence of voids, fissures, and other flaws

The alterations in the concrete's structure that arise from exposure conditions or wear over time.
• The concrete's quality in respect to the required standard specifications.

• to the opposing component.

1.2 WAMs (WASTE ALTERNATE MATERIALS)

Stricter environmental regulations and pollution controls have led to an increase in industrial wastes and subgraded derivatives, such fly ash and silica fume, that can be used as waste activated mass materials (WAMs). In addition to preventing these materials from contributing to pollution, the use of WAMs in concrete building enhances the properties of the material when it is still fresh and hydrated.
Based on the sort of response they exhibit, the WAMs may be classified into two classes: pozzolanic and hydraulic. Concrete like GGBS is created when hydraulic ingredients and water undergo a complete reaction. Although pozzolanic materials don't have any cementitious properties, they react with calcium hydroxide when they are used with lime or cement to produce products that do.

1.2.1 MARBLE POWDER AS WAMs

The advancement of concrete technology can reduce the amount of energy and natural resources used, as well as the amount of pollutants released into the atmosphere.

Fig. 1.2 Marble Powder

concrete have been examined, and furthermore accelerated aging tests. Results demonstrate is that concrete with fractional cement replacement by ceramic powder although it has have slight strength loss have increase durability performance. Results alsodemonstrated that concrete mixtures with ceramic aggregates execute better than the control concrete mixtures regarding crushing strength, capillary absorption of water, penetration of oxygen and chloride diffusion. The substitution of cement and aggregates in concrete by ceramic wastes will have chief environmental profits.

Stone that has undergone metamorphism is marble, which originated from pure limestone. The primary cause of the marble's colour and appearance is its purity.If the limestone is made entirely of calcite, it is white. Marble is used in both building and decoration; it is highly sought after due to its durability and noble beauty. Calcite, dolomite, and serpentine minerals make up the majority of the crystalline rocks that make up marbles. The other mineral components differ based on where they come from. The primary mineral impurities associated with marble are quartz, talc, garnet, osterite, muscovite, tremolite, actinolite, micro line, and biotite. The primary chemical impurities associated with marble are Fe2O3, manganese, SiO2, limonite, 3H2O, and FeS2. The primary contaminants found in raw limestone that might affect the characteristics of cement once it is completed include

1.2.2 STEEL SLAG

Fig 1.3 – Steel Slag

1.3 Effect of aggregates shape

It has been proved by previous researches that a among the voids of aggregates and shape, texture and grading of aggregates exists.
In rounded, cubical and well graded particles reveals lesser void content than flaky or elongated aggregates. Shapes such as circular or angular are recognized as significant characteristic.
Roundness can be detected by determining the convexity and angularity pointed the corners' and edges' crispness. On the other hand, elongated and flaky particles can produce harsh mixes and have a significant impact on workability. Overabundance of irregularly shaped particles may weaken concrete by increasing water consumption. Furthermore, the strength and longevity of concrete may be harmed by the orientation of flat particles.
Hence, it has been accomplished that the characteristics of concrete were affected bythe quality and quantity of aggregates, the cement paste and the paste-aggregate bond characteristics.
Other behaviors of concrete such as durability and abrasion resistance are also highly dependent on the aggregate, which consecutively depends on strength of parent rock, purity, surface texture, gradation and so on.
The elongated and flaky aggregate prevented the creation of concrete with exceptional qualities. The concrete mixes deteriorate more quickly when there are flaky and elongated particles present in excess of a specific threshold. Low workability and abrasive mixes are produced by a large proportion of flaky and elongated particles. This inquiry has attempted to investigate the viability of using such aggregate in cement concrete.

1.4 Proposed objective and outcomes

1. The main aim of this research is to determine the mechanical properties of cement concrete produced by using steel slag as a normal aggregate replacement for flat aggregates and compare it in terms of slump value and load-bearing capacity.
2. In this present study Effects with the two types of aggregate on workability and compressive strength of concrete require to be investigated in the concretes produced by fusion of sand with marble powder.
3. The following parameters have been set up —
4. Workability

1.5 Methodology adopted in present research

Following is the methodology to be adopted for performing this study

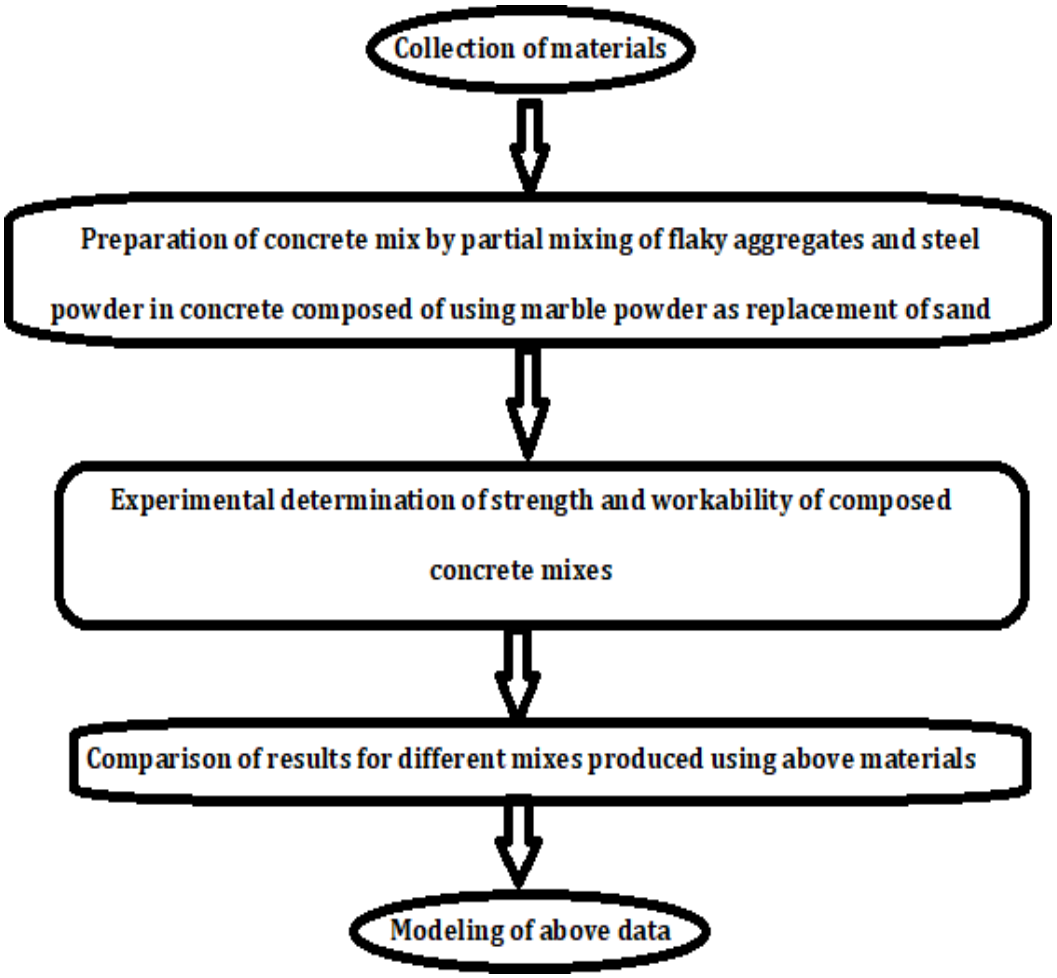


Fig.- Methodology

1.6 ORGANIZATION OF THESIS:

This thesis consists of following chapters -

1) **Chapter 1 - Introduction:** Presents introduction intended to the background of the thesis as well as the objectives and methodologies.
2) **Chapter 2 - Literature Review:** Presents the overview of research papers considered relevant, with regard to the present study.
3) **Chapter 3 –Materials used and parameters tested** Describes the methodology of the present research with the WAMs used in the presents research tests performed to determine the physical and chemical properties cement and aggregates.
4) **Chapter 4 – Experimental results and analysis** This chapter shows the results of tests conducted over prepared concrete specimens
5) **Chapter 5 – ANN Modeling** – Presents the artificial neural network (ANN) to determine the relation among the determined parameters.
6) **Chapter 6 – Conclusions and discussions** Presents both general and specific conclusions and the further scope of the study.

CHAPTER 2

Literature Review

Coarse aggregate are a chief part of concrete it takes a elevated percentage concrete. Several researchers‟ made from non-traditional shape aggregates. Presents work of several researchers are shown below.

Ponnada et al. [2014] Evaluated combined. M 35 grade has been considered had been experienced different characteristicsf prepared concrete.

Muhit et al. [2013] Examined due to different types of aggregates. Different

Jakarsi et al. [2013] Results. of laboratory tests have been considered for finding the effects of flaky dimensioned aggregates on characteristics, of concrete. Marshall Mix Design has been used for estimating all the mix designs.

Singh and Biswas et al. [2013] Found that area of flaky aggregates is relatively higher than those of normal aggregates which results in increased bitumen content in mix. During the actual work, the grading and size of the aggregates change from the one in the job method.

Naidu and Adiseshu et al. [2013] Found that strength and serviceability of hot mixes highly rely over physical properties of aggregate. Dense bituminous macadam mixes had been analyzed with dissimilar proportions of different shapes of aggregates studies.

Jain and Chouhan et al. [2011] Determined that shape of aggregate used in manufacturing of concrete is remarkable for compressive strength and permeability of pervious concrete. Laboratory experiments have been conducted on mixes of pervious concrete prepared using aggregates of different shape with varying water cement ratio.

Othman et al. [2010] Concluded that Marshal test results of different type‟s coarse cubical aggregate in varying percentages will show the sizeable effect of shapes on mix properties.

Vyawahare and Modani et al. [2009] Performed a study to improve the workability and strength of concrete with flaky and elongated aggregates using super-plasticizer with other admixture for determining the allowable percentages of aggregates in the concrete mixes.

Westerholm et al. [2008] Presented the results obtained by performing a laboratory investigation over the rheological properties, such as yield stress and viscosity of the concrete. The consequence of grading and particle shape of the sand has been investigated using proper equipments. The results of experiments illustrate that the quantity and characteristics of sand influenced the properties of mortar such as consistency and workability. The influence of the sand properties significantly depends over the quantity of mortar.

Several researchers used steel slag in place of coarse aggregate to determine the properties of produced concrete. Few of them are presented in below lines.

Bernal et al. [2010] Investigated the improvement of concrete strength using steel slag. They found that using steel slag enhanced both crushing and splitting tensile strengths compared to ordinary cement concrete.

Qasrawi et al. [2009] Explored the use of untreated steel slag as a fine aggregate in concrete. Concluded that steel slag concrete shows higher compressive and tensile strengths, particularly beneficial for lower strength concretes.

Boukendakdji et al. [2009] Studied the effect of steel slag on the rheology of self- compacting concrete. Concluded that steel slag can produce good self-compacting concretebased on experimental results.

Wu et al. [2007] Examined the use of steel slag as aggregates for Stone Mastic Asphalt (SMA) mixtures. Concluded that SMA mixtures with steel slag aggregates exhibited exceptional performance even after two years of service.

Maslehuddin et al. [2003] Compared the characteristics of concrete using steel slag versuscrushed limestone aggregate. Found that steel slag concrete showed superior resilience characteristics compared to concrete using crushed limestone aggregate, with certain physical features demonstrating better performance.

These studies collectively highlight the potential benefits of incorporating steel slag into concrete mixes, including improved strength properties, enhanced durability, and favorable rheological characteristics for specialized applications

like self-compacting concrete and asphalt mixtures. Utilizing industrial by-products like steel slag in construction materials can also contribute to sustainable practices by reducing waste and resource consumption.

Marble powder has been mixed to cement by several researchers for producing blended cement, few of these researches has been presented in below paragraph.

Aliabdo et al. [2014] Investigated the use of waste marble dust in cement and concrete production. Marble dust was added in varying proportions (0.0%, 5.0%, 7.5%, 10%, and 15% by weight of cement and sand). The study found that replacing sand with marble dust resulted in better concrete performance compared to replacing cement.

Singh and Nanda et al. [2012] Studied mortars prepared by replacing cement with marble powder. They evaluated parameters such as crushing strength, flexural strength, and

workability. The research observed a notable reduction in crushing strength with increased marble powder content, while workability remained moderate.

Aruntaş et al. [2010] Examined the use of waste marble powder as an additive to cementin concrete and evaluated strength after different curing periods (7, 28, and 90 days). Concluded that incorporating 10% marble powder resulted in concrete with optimal strength and workability.

These studies highlight the potential of utilizing waste marble powder as a partial replacement for cement or sand in concrete production. The findings suggest that incorporating marble powder can affect concrete properties such as strength and workability, with optimal performance achieved at specific substitution rates. This approach contributes to sustainable construction practices by recycling waste materials and improving the performance characteristics of concrete.

Chapter 3
Materials Used and Parameters Tested

Describes the methodology of the present research with the WAMs used in the presents research tests performed to determine the physical and chemical properties of cement and aggregates.

3.1 Flaky Aggregates

Concrete is normally composed of mixing cement and sand paste with coarse aggregates. Although a reaction to harden the paste strength gains is performed chemically to make stone hard concrete caaled hydration of cement.
Residential or commercial structures situated worldwide considered concrete as significant part of buildings.
Cement as a binder is most used material in construction industry because –

1) Highly workable
2) Raw material is easily available
3) Good characteristics
4) Large literature is available
5) Simple testing procedures
6) Durable and reliable
7) Heat and cold resistant
8) Highly resistant to other weather effects
9) Can blend with other inert materials

Aggregates are very significant parts of concrete. An ideal aggregate used for the manufacturing ofconcrete and mortar, should meet the following requirements.

(1) Consist of stones from nature or sand.
(2) Hard and durable
(3) Dense and free from flaws and coating.

(4) Free from injurious vegetable matters.

(5) Flaky and elongated shapes were avoided.

(6) No harmful content may present in it.

(7) Steel must be protected.

3.1.1 Determination of shape and elongationShape tests

Figure 3.1 - Flakiness gauge

The aggregate shape index can be evaluated as the percentage of flaky and elongated particles in it. Flaky or elongated aggregates are detrimental to higher workability and stability. The flakiness indexis defined as the percentage by mass of aggregate parts whose smallest amount dimension is < 0.6 times their average size. Experiment process had been regular in India (IS:2386 part-I).

The elongation index of aggregates is defined as the percentage by weight of particles whose maximum length is > 1.8 times their mean dimension. This test is related to aggregates larger than 6.3 mm. This test is also specified in (IS: 2386 Part-I)

Figure 3.2- Elongation gauge

3.2 Marble Powder

Good amount of powder is produced during the process of cutting. About 20% of marble quarried is converted into waste during cutting. The worldwide utilization of natural sand is too large due to its broad use in concrete. The demand of natural sand is quite large in developed/developing countries owing to quick infrastructural growth which result in supply scarcity. To conquer this crisis, fractional replacement of natural sand with marble powder is economic substitute. Concrete industry is continually watching for supplementary material with the purpose of reducing the solid waste disposal problem, marble powder is among the solid wastes produced by the different industry. Waste material from marble industry can be used to enhance several properties of fresh and hardened concrete.

The collection of waste materials to the surroundings directly can cause environmental problem, waste can be used to generate new products or can be utilized as admixtures so that natural resources and the environment is protected.

3.3 Steel Slag

Steel slag is the by-product of steel manufacture process and consists of silicates and oxides of unnecessary elements in steel chemical composition. Fifty million tons every year of LD slag were generated as a residue from Basic Oxygen Process in the world.

In order to utilize these in cement, their hydraulic properties must be known. Chemical composition is one of the significant factors evaluating the hydraulic features of the slags. In general, itis supposed that the higher the alkalinity, the higher the hydraulic properties. If alkalinity is more than 1.8, it should be believed as cementitious material.

Studies were performed also on the usability of steel slag as construction material under different laboratory and practical conditions. For this purpose, the required features are high crushing strength, resistance to climatic conditions and wear strength. The most significant criterion is volume stability, in which free CaO and MgO contents of the slag play a vital role. Both oxides can go into reaction with water. Hydration causes volume expansion and influences stability of volume. This is thereason why steel slag aggregate are not appropriate for use in Portland cement concrete.

3.4 Parameters Selected

Type of ingredient and admixture affects the several physical and chemical properties of the concrete and mortar. Here in the present work, properties of concrete such as compressive strength andworkability are identified and evaluated for investigating the effect different admixtures and type of aggregates.

3.4.1 Compressive Strength

Out of many test applied to the concrete, this is the utmost important

Fig 3.3 – Cube Mould

Apparatus:- Compression testing machine

Fig. 3.5 compression testing machine

4.2.2 Workability of Concrete

The behavior of green or fresh concrete from mixing up to compaction depends mainly on the property called "workability of concrete". Workability of concrete is a term which consistsof the following four partial properties of concrete namely, Mixability, Transportability, Mouldability and Compactibility. The slump is a measure indicating the consistency or workability of cement concrete.It gives an idea of water content needed for concrete to be used for different works.

Apparatus: Slump Cone Apparatus

Fig. 4.4 Slump cone apparatus

PROCEDURE:

Four mixes are to be prepared with water-cement ratio (by mass) of 0.50, 0.60, 0.70 and 0.80, respectively, and for each mix take 10 kg of coarse aggregates, 5kg of sand and 2.5kg of cement with each mix proceed as follows –

1) concrete in the cleaned slump cone mould in 4 layers, each approximately ¼ of the height of the mould. Tamp

each layer 25 times with tamping rod distributing the strokes in a uniform manner over the cross-section of the mould. For the second and subsequent layers the tamping rod should penetrate in to the underlying layer.

2) Strike off the top with a trowel or tamping rod so that the mould is exactly filled.

3) Remove the cone immediately, raising it slowly and carefully in the vertical direction.

4) As soon as the concrete settlement comes to a stop, measure the subsidence of concrete in mm which will give the slump.

Slump test is adopted in the laboratory or during the progress of work in the field for determining consistency of concrete where nominal maximum size of aggregate does not exceed 40mm. Any slump specimen, which collapses or shears off laterally gives incorrect results and if this occurs the test is repeated, only the true slump should be measured.

CHAPTER 4

Experimental Results

4.1 Experimental Investigations

Several laboratory experiments have been conducted to perform investigation. Several concrete mixes of target strength 20 MPa have been casted by partial use of flaky aggregate or steel slag with blended cement. Ordinary Portland cement of grade 43 has been used for this study. Fine aggregate used was river sand with fineness modulus 2.25, w/c ratio for each concrete mix is taken as from 0.45 to 0.55. Sand has been mixed with marble powder in two different ratios 1:1 and 1:0.5.

Mixes were produced by replacing coarse aggregate with flaky aggregate and steel slag in different proportions such as 5%, 10%, 15%, 20%, 25% and 30%% for each variation of sand and marble powder. Mix design has been performed for target strength of 20 MPa and following proportion of ingredients has been obtained.

Table 4.1 Proportion of all the ingredients in M-20 mix

Water	Cement	Sand	Coarse aggregate
0.5	1	1.62	3.4

114 types of concrete mixes have been prepared by varying proportions of sand, marblepowder, flaky aggregates, steel slag, normal aggregates and water to cement ratio. For each sand to marble powder ratio (1:1 and 1:0.5), coarse aggregate has been partially replaced by flaky aggregate, steel slag and their composite mixture. For each replacement of aggregates three different water cement ratios 0.45, 0.5 and 0.55 have been considered. Table 4.2 presents the compositions ofprepared concrete mixtures.

Table 4.2 weight of ingredients (Kg) in prepared Concrete mixes

S. No.	Concrete Mix	Cement	% Replacement of coarse aggregates	w/c ratio	Fine Aggregates		Coarse Aggregates		
					Sand	Marble Powder	Flaky	Steel Slag	Normal
Sand/ Marble Powder (1:1)									
1	Cx1	1	0%	0.45	0.81	0.81	0	0	3
2	Cx2	1	0%	0.5	0.81	0.81	0	0	3
3	Cx3	1	0%	0.55	0.81	0.81	0	0	3
4	Cx4	1	5%	0.45	0.81	0.81	0.17	0	3
5	Cx5	1	5%	0.5	0.81	0.81	0.17	0	3
6	Cx6	1	5%	0.55	0.81	0.81	0.17	0	3
7	Cx7	1	10%	0.45	0.81	0.81	0.34	0	3
8	Cx8	1	10%	0.5	0.81	0.81	0.34	0	3

9	Cx9	1	10%	0.55	0.81	0.81	0.34	0	3
10	Cx10	1	15%	0.45	0.81	0.81	0.51	0	3
11	Cx11	1	15%	0.5	0.81	0.81	0.51	0	3
12	Cx12	1	15%	0.55	0.81	0.81	0.51	0	3
13	Cx13	1	20%	0.45	0.81	0.81	0.68	0	3
14	Cx14	1	20%	0.5	0.81	0.81	0.68	0	3
15	Cx15	1	20%	0.55	0.81	0.81	0.68	0	3
16	Cx16	1	25%	0.45	0.81	0.81	0.85	0	3
17	Cx17	1	25%	0.5	0.81	0.81	0.85	0	3
18	Cx18	1	25%	0.55	0.81	0.81	0.85	0	3
19	Cx19	1	30%	0.45	0.81	0.81	1.02	0	2
20	Cx20	1	30%	0.5	0.81	0.81	1.02	0	2
21	Cx21	1	30%	0.55	0.81	0.81	1.02	0	2
22	Cx22	1	5%	0.45	0.81	0.81	0	0	3
23	Cx23	1	5%	0.5	0.81	0.81	0	0	3
24	Cx24	1	5%	0.55	0.81	0.81	0	0	3
25	Cx25	1	10%	0.45	0.81	0.81	0	0	3

26	Cx26	1	10%	0.5	0.81	0.81	0	0	3
27	Cx27	1	10%	0.55	0.81	0.81	0	0	3
28	Cx28	1	15%	0.45	0.81	0.81	0	1	3
29	Cx29	1	15%	0.5	0.81	0.81	0	1	3
30	Cx30	1	15%	0.55	0.81	0.81	0	1	3
31	Cx31	1	20%	0.45	0.81	0.81	0	1	3
32	Cx32	1	20%	0.5	0.81	0.81	0	1	3
33	Cx33	1	20%	0.55	0.81	0.81	0	1	3
34	Cx34	1	25%	0.45	0.81	0.81	0	1	3
35	Cx35	1	25%	0.5	0.81	0.81	0	1	3
36	Cx36	1	25%	0.55	0.81	0.81	0	1	3
37	Cx37	1	30%	0.45	0.81	0.81	0	1	2
38	Cx38	1	30%	0.5	0.81	0.81	0	1	2
39	Cx39	1	30%	0.55	0.81	0.81	0	1	2
40	Cx40	1	5%	0.45	0.81	0.81	0.09	0	3
41	Cx41	1	5%	0.5	0.81	0.81	0.09	0	3
42	Cx42	1	5%	0.55	0.81	0.81	0.09	0	3

43	Cx43	1	10%	0.45	0.81	0.81	0.17	0	3
44	Cx44	1	10%	0.5	0.81	0.81	0.17	0	3
45	Cx45	1	10%	0.55	0.81	0.81	0.17	0	3
46	Cx46	1	15%	0.45	0.81	0.81	0.26	0	3
47	Cx47	1	15%	0.5	0.81	0.81	0.26	0	3
48	Cx48	1	15%	0.55	0.81	0.81	0.26	0	3
49	Cx49	1	20%	0.45	0.81	0.81	0.34	0	3
50	Cx50	1	20%	0.5	0.81	0.81	0.34	0	3
51	Cx51	1	20%	0.55	0.81	0.81	0.34	0	3
52	Cx52	1	25%	0.45	0.81	0.81	0.43	0	3
53	Cx53	1	25%	0.5	0.81	0.81	0.43	0	3
54	Cx54	1	25%	0.55	0.81	0.81	0.43	0	3
55	Cx55	1	30%	0.45	0.81	0.81	0.51	1	2
56	Cx56	1	30%	0.5	0.81	0.81	0.51	1	2
57	Cx57	1	30%	0.55	0.81	0.81	0.51	1	2

weight of ingredients (Kg) in prepared Concrete mixes Sand/ Marble Powder (1:0.5)									
58	Cy1	1	0%	0.45	1.08	0.54	0	0	3
59	Cy2	1	0%	0.5	1.08	0.54	0	0	3
60	Cy3	1	0%	0.55	1.08	0.54	0	0	3
61	Cy4	1	5%	0.45	1.08	0.54	0.17	0	3
62	Cy5	1	5%	0.5	1.08	0.54	0.17	0	3
63	Cy6	1	5%	0.55	1.08	0.54	0.17	0	3
64	Cy7	1	10%	0.45	1.08	0.54	0.34	0	3
65	Cy8	1	10%	0.5	1.08	0.54	0.34	0	3
66	Cy9	1	10%	0.55	1.08	0.54	0.34	0	3
67	Cy10	1	15%	0.45	1.08	0.54	0.51	0	3
68	Cy11	1	15%	0.5	1.08	0.54	0.51	0	3
69	Cy12	1	15%	0.55	1.08	0.54	0.51	0	3
70	Cy13	1	20%	0.45	1.08	0.54	0.68	0	3
71	Cy14	1	20%	0.5	1.08	0.54	0.68	0	3
72	Cy15	1	20%	0.55	1.08	0.54	0.68	0	3
73	Cy16	1	25%	0.45	1.08	0.54	0.85	0	3
74	Cy17	1	25%	0.5	1.08	0.54	0.85	0	3
75	Cy18	1	25%	0.55	1.08	0.54	0.85	0	3

76	Cy19	1	30%	0.45	1.08	0.54	1.02	0	2
77	Cy20	1	30%	0.5	1.08	0.54	1.02	0	2
78	Cy21	1	30%	0.55	1.08	0.54	1.02	0	2
79	Cy22	1	5%	0.45	1.08	0.54	0	0	3
80	Cy23	1	5%	0.5	1.08	0.54	0	0	3
81	Cy24	1	5%	0.55	1.08	0.54	0	0	3
82	Cy25	1	10%	0.45	1.08	0.54	0	0	3
83	Cy26	1	10%	0.5	1.08	0.54	0	0	3
84	Cy27	1	10%	0.55	1.08	0.54	0	0	3
85	Cy28	1	15%	0.45	1.08	0.54	0	1	3
86	Cy29	1	15%	0.5	1.08	0.54	0	1	3
87	Cy30	1	15%	0.55	1.08	0.54	0	1	3
88	Cy31	1	20%	0.45	1.08	0.54	0	1	3
89	Cy32	1	20%	0.5	1.08	0.54	0	1	3
90	Cy33	1	20%	0.55	1.08	0.54	0	1	3
91	Cy34	1	25%	0.45	1.08	0.54	0	1	3
92	Cy35	1	25%	0.5	1.08	0.54	0	1	3
93	Cy36	1	25%	0.55	1.08	0.54	0	1	3
94	Cy37	1	30%	0.45	1.08	0.54	0	1	2

95	Cy38	1	30%	0.5	1.08	0.54	0	1	2
96	Cy39	1	30%	0.55	1.08	0.54	0	1	2
97	Cy40	1	5%	0.45	1.08	0.54	0.09	0	3
98	Cy41	1	5%	0.5	1.08	0.54	0.09	0	3
99	Cy42	1	5%	0.55	1.08	0.54	0.09	0	3
100	Cy43	1	10%	0.45	1.08	0.54	0.17	0	3
101	Cy44	1	10%	0.5	1.08	0.54	0.17	0	3
102	Cy45	1	10%	0.55	1.08	0.54	0.17	0	3
103	Cy46	1	15%	0.45	1.08	0.54	0.26	0	3
104	Cy47	1	15%	0.5	1.08	0.54	0.26	0	3
105	Cy48	1	15%	0.55	1.08	0.54	0.26	0	3
106	Cy49	1	20%	0.45	1.08	0.54	0.34	0	3
107	Cy50	1	20%	0.5	1.08	0.54	0.34	0	3
108	Cy51	1	20%	0.55	1.08	0.54	0.34	0	3
109	Cy52	1	25%	0.45	1.08	0.54	0.43	0	3
110	Cy53	1	25%	0.5	1.08	0.54	0.43	0	3
111	Cy54	1	25%	0.55	1.08	0.54	0.43	0	3
112	Cy55	1	30%	0.45	1.08	0.54	0.51	1	2
113	Cy56	1	30%	0.5	1.08	0.54	0.51	1	2

Two laboratory experiments, compression test and slump cone test, have been conducted onthe prepared concrete mixes. Results of these experiments have been shown in table 4.3.

Table 4.3 – Results of compressive strength and slump cone tests

S. No.	ConcreteMix	Compressive strength	Slump value in mm
1	Cx1	19.2	97
2	Cx2	19. 4	95
3	Cx3	19.9	94
4	Cx4	18.6	93
5	Cx5	18.9	91
6	Cx6	19.4	88
7	Cx7	18.4	89
8	Cx8	18.7	87
9	Cx9	19.3	84
10	Cx10	18.1	86
11	Cx11	18.7	83
12	Cx12	19.1	82
13	Cx13	17.9	82

14	Cx14	18.3	80
15	Cx15	18.6	77
16	Cx16	17.6	79
17	Cx17	18.2	77
18	Cx18	18.5	74
19	Cx19	17.1	76
20	Cx20	17.8	73
21	Cx21	18	72
22	Cx22	19.6	92
23	Cx23	19. 8	90
24	Cx24	20.3	89
25	Cx25	19.8	91
26	Cx26	20.1	88
27	Cx27	20.7	84
28	Cx28	19.9	86
29	Cx29	20.4	83

30	Cx30	20.8	81
31	Cx31	20.1	82
32	Cx32	20.7	77
33	Cx33	21.1	74
34	Cx34	20.3	80
35	Cx35	20.8	76
36	Cx36	21.3	74
37	Cx37	20.7	79
38	Cx38	21.2	75
39	Cx39	21.5	72
40	Cx40	19.2	91
41	Cx41	19. 4	88
42	Cx42	19.7	87
43	Cx43	19.3	89
44	Cx44	19.6	87
45	Cx45	19.8	84

46	Cx46	19.5	85
47	Cx47	19.9	82
48	Cx48	20.2	80
49	Cx49	19.9	81
50	Cx50	20.3	77
51	Cx51	20.6	74
52	Cx52	20.1	80
53	Cx53	20.4	75
54	Cx54	20.7	72
55	Cx55	20.3	77
56	Cx56	20.8	73
57	Cx57	21.1	69
58	Cy1	19.1	99
59	Cy2	19. 3	96
60	Cy3	19.8	94
61	Cy4	18.4	97

62	Cy5	18.6	93
63	Cy6	19.1	91
64	Cy7	18.1	92
65	Cy8	18.4	89
66	Cy9	19.1	87
67	Cy10	18.1	89
68	Cy11	18.5	87
69	Cy12	19.8	84
70	Cy13	17.8	85
71	Cy14	18.1	82
72	Cy15	18.2	79
73	Cy16	17.3	83
74	Cy17	18	79
75	Cy18	18.2	78
76	Cy19	17	81

77	Cy20	17.4	79
78	Cy21	17.8	76
79	Cy22	19.2	95
80	Cy23	19. 4	93
81	Cy24	20	90
82	Cy25	19.5	94
83	Cy26	19.8	91
84	Cy27	20.1	88
85	Cy28	19.4	89
86	Cy29	19.9	86
87	Cy30	20.2	85
88	Cy31	19.9	88
89	Cy32	20.3	85
90	Cy33	19.1	83

91	Cy34	19.4	83
92	Cy35	20.1	80
93	Cy36	20.4	78
94	Cy37	20.7	81
95	Cy38	20.9	79
96	Cy39	21.5	76
97	Cy40	19	93
98	Cy41	19.3	89
99	Cy42	19.5	87
100	Cy43	19.1	91
101	Cy44	19.4	88
102	Cy45	19.7	87
103	Cy46	19.3	88
104	Cy47	19.4	86

105	Cy48	19.8	83
106	Cy49	19.6	86
107	Cy50	20.1	83
108	Cy51	20.4	81
109	Cy52	19.8	84
110	Cy53	20.1	81
111	Cy54	20.3	79
112	Cy55	19.7	81
113	Cy56	20.1	79
114	Cy57	20.4	76

From the table 4.3 which presents the results of experiments performed to determine thecompressive strength and workability of concrete, following inferences have been drawn

1. Increase in proportion of flaky aggregates reduces the compressive strength andslump value of concrete.
2. Increase in percentage of Steel slag increases the compressive strength anddecreases the workability of concrete.
3. Increase in percentage of Marble powder reduces the strength and workability ofconcrete.
4. With the increase in water cement ratio compressive strength for a fixedreplacement of aggregate increases and workability reduces.

CHAPTER 5

ANN Modeling

To obtain the combined effect of proportions of flaky aggregates, steel aggregates and marblepowder artificial neural network (ANN) has been used in the present research.

5.1 PROPOSED MODEL FOR COMPRESSIVE STRENGTH

In this study, the artificial neural network based analytical model is proposed, in which Multi layer feed Forward Network is used.

Various elements of structure are tabulated in Table-5.1.

Table- 5.1 Multi layer feed Forward Network

Neural Network	MLP
Number of Input Variables	7
Number of Hidden Layer	2
Number of Hidden Neuron in First Hiddenlayer	20
Activation function used in first hidden layer	Straight line

Neural Network Input Variables used for parametric study are tabulated in Table-5.2.

Table- 5.2 Neural Network Input Variables

S. No.	**Input Data**		**Range**
1	% Replacement of coarse aggregates		0-30%
2	w/c ratio		0.45-0.55
3	Fine Aggregates	Sand	0.81-1.08
		Marble Powder	0.54-0.81
4	Coarse Aggregates	Flaky	0-1.02
		Steel Slag	0-1.02
		Normal	2.38-3.4

PROCEDURAL STEPS FOR MODELLING

STEP 1-Matrix is formed for both input and target data in work space.

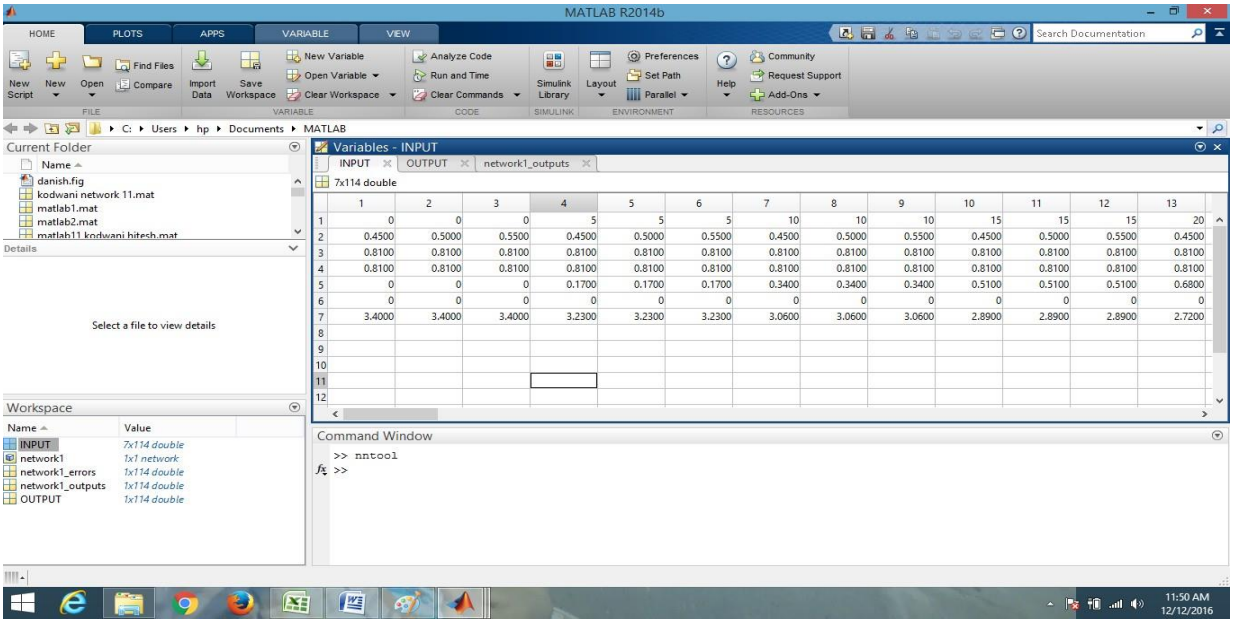


Fig.5.1 PROCEDURAL STEPS FOR MODELLING

STEP 2-Data transferred to Data manager.

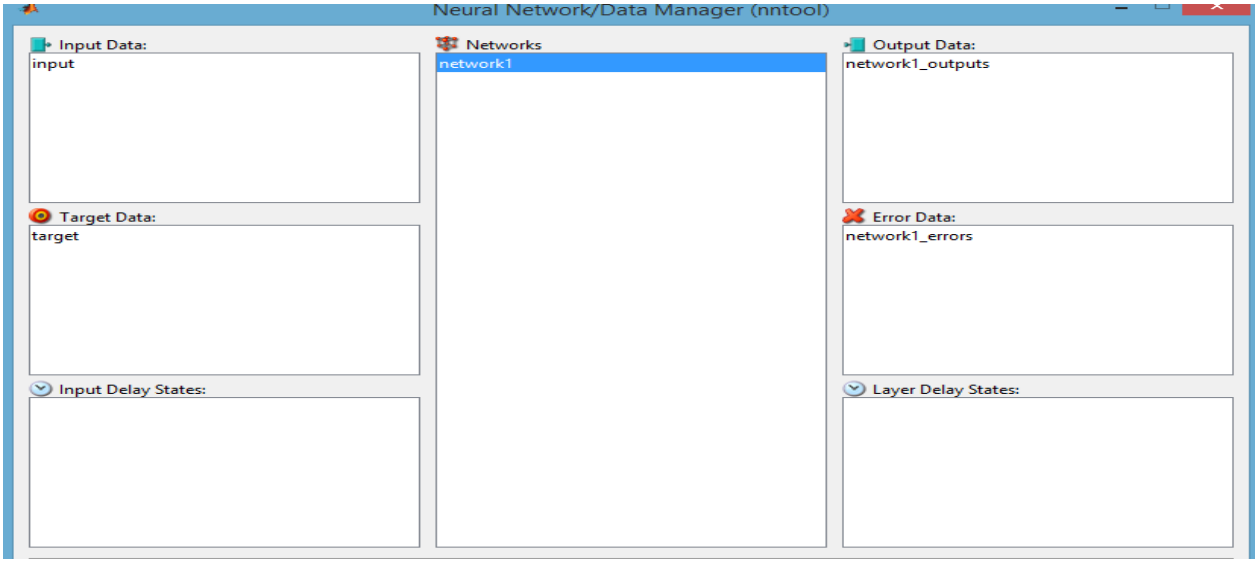


Fig.5.2 Data transferred to Data manager

STEP 3- Set network type, number of layers and neurons to be used and create network.

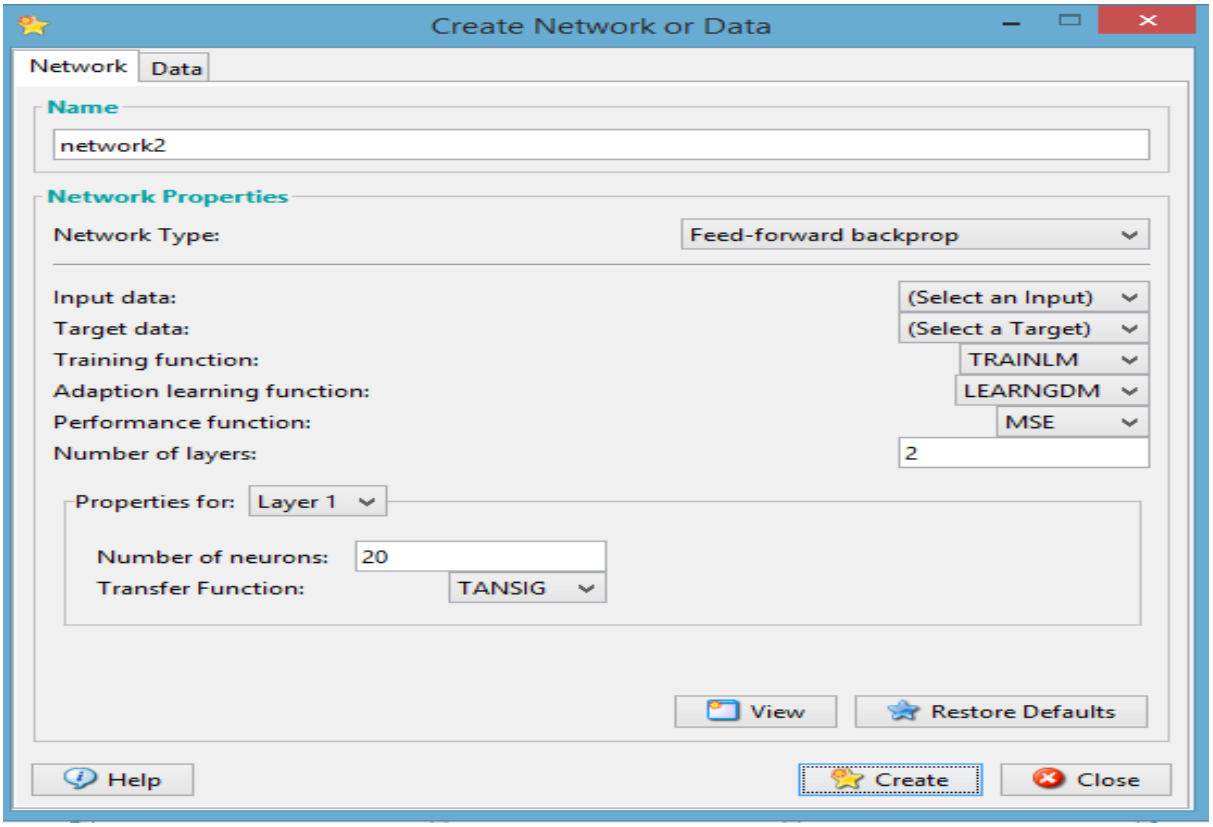


Fig.5.3 Set Network type, number of layers

STEP 4-After creating network, training is to be done.

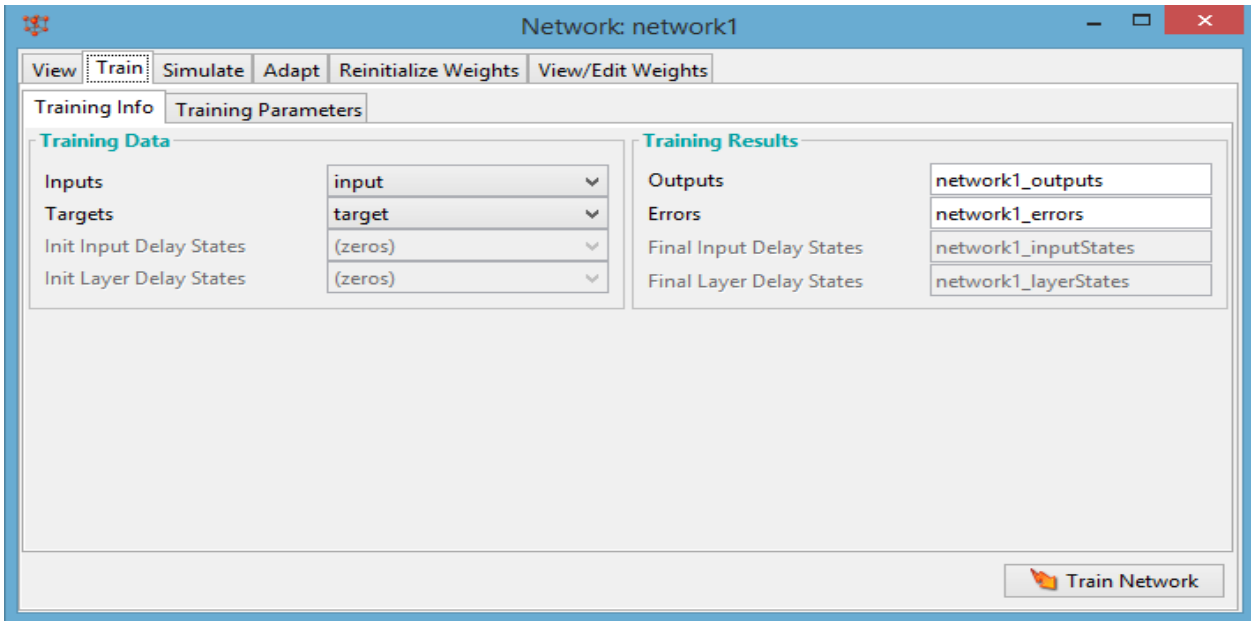


Fig.5.4 creating network

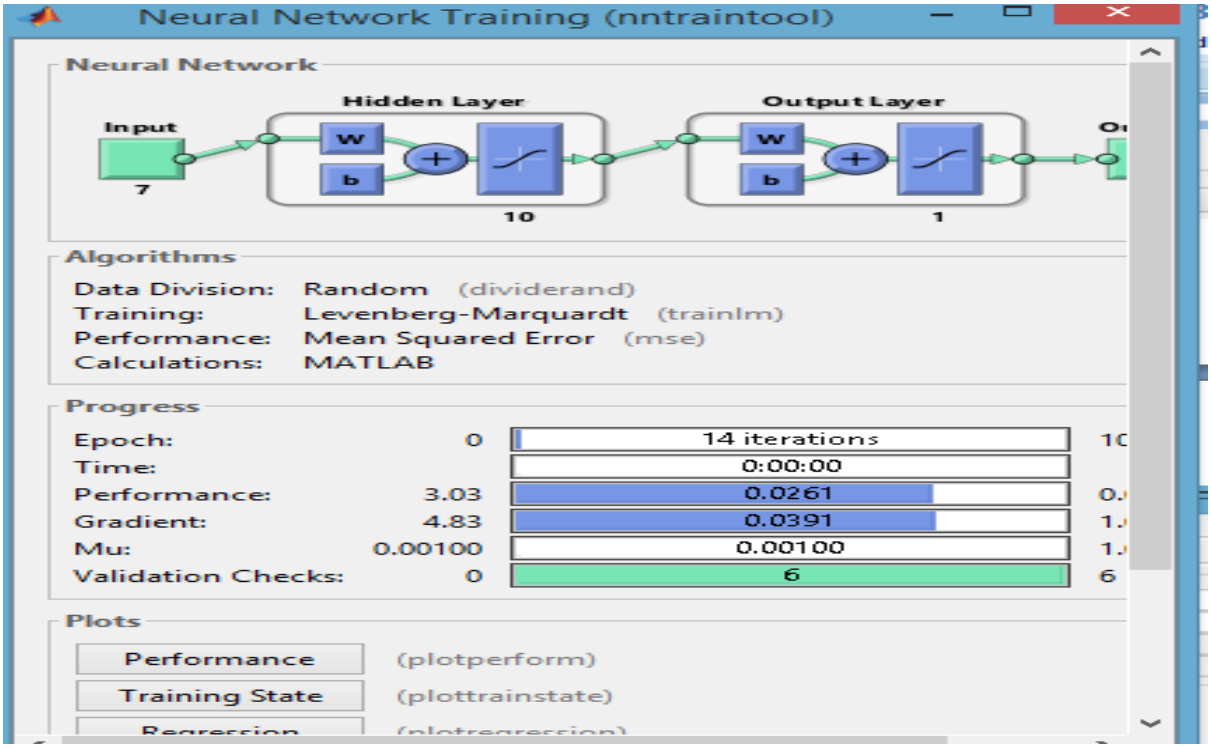


Fig.5.5 Neural Network Training

STEP 5- Finally performance graph can be obtained.

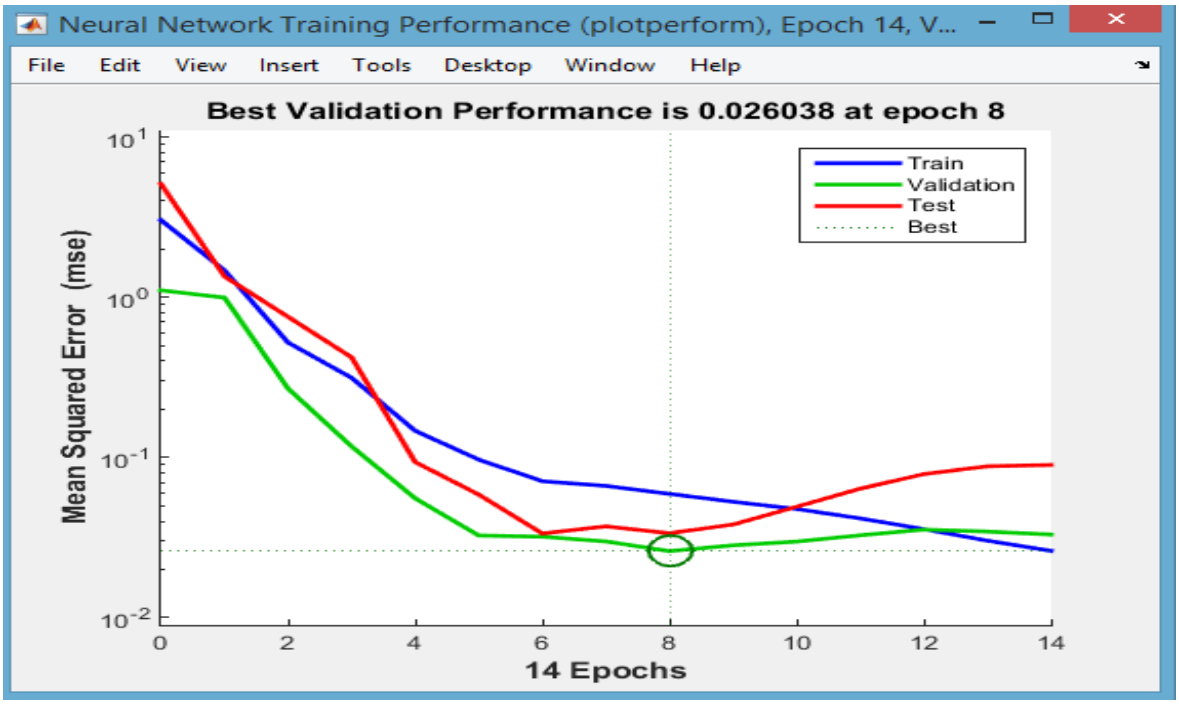


Fig.5.6 Performance graph

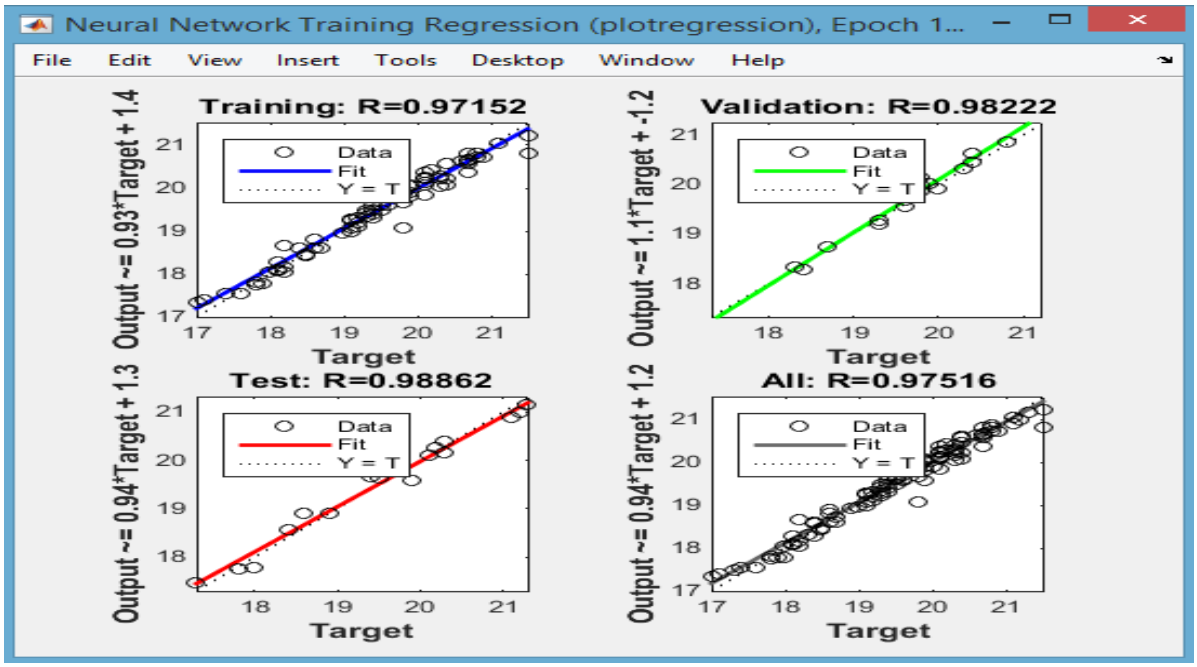


Fig.5.7 Plot regression

Table 5.3 Values of Regression Coefficient

S. No.	Data set	Value of R
1	Training	0.972
2	Validation	0.982
3	Test	0.989
4	All	0.975

Fig. 5.7 and table 5.6 provide the results of all the three data set using training, testing and validationdata with whole data considering value of „R‟ correlation coefficient. Value of „R‟ indicates similaritybetween two data series, it value ranges from -1 to +1. A larger value of „R‟ indicates bettercorrelation. It has been observed from table 5.3, that value of „R‟ between output from model and target value, for all the three sets of data is reaching „1‟ which indicates a good correlation.

STEP 6- Obtained network exported to workspace to view the predicted results and error (differencefrom original results)

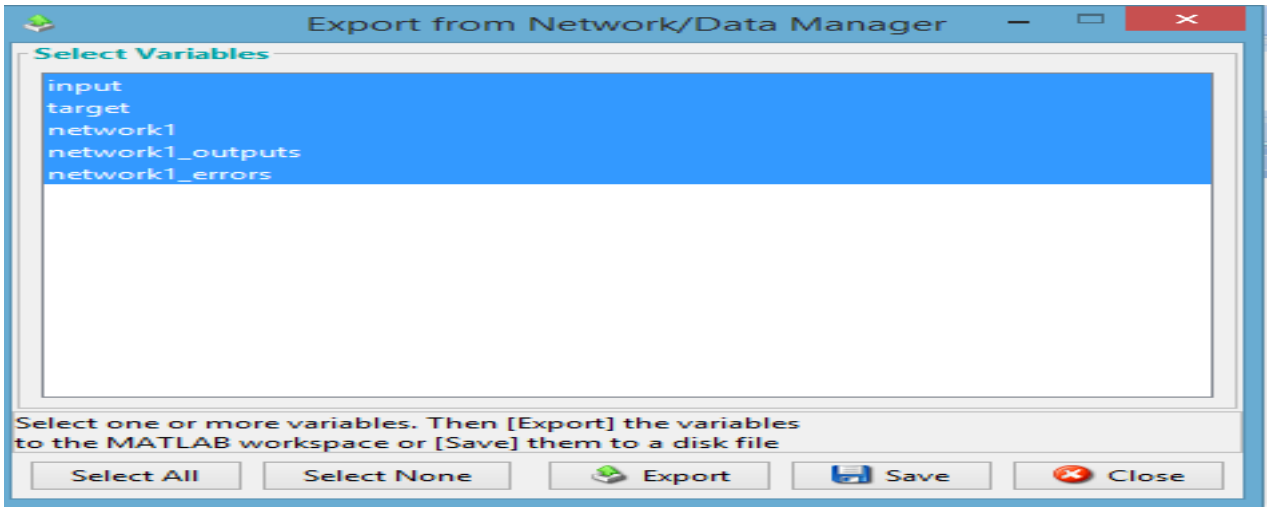


Fig.5.8 Exported to workspace to view

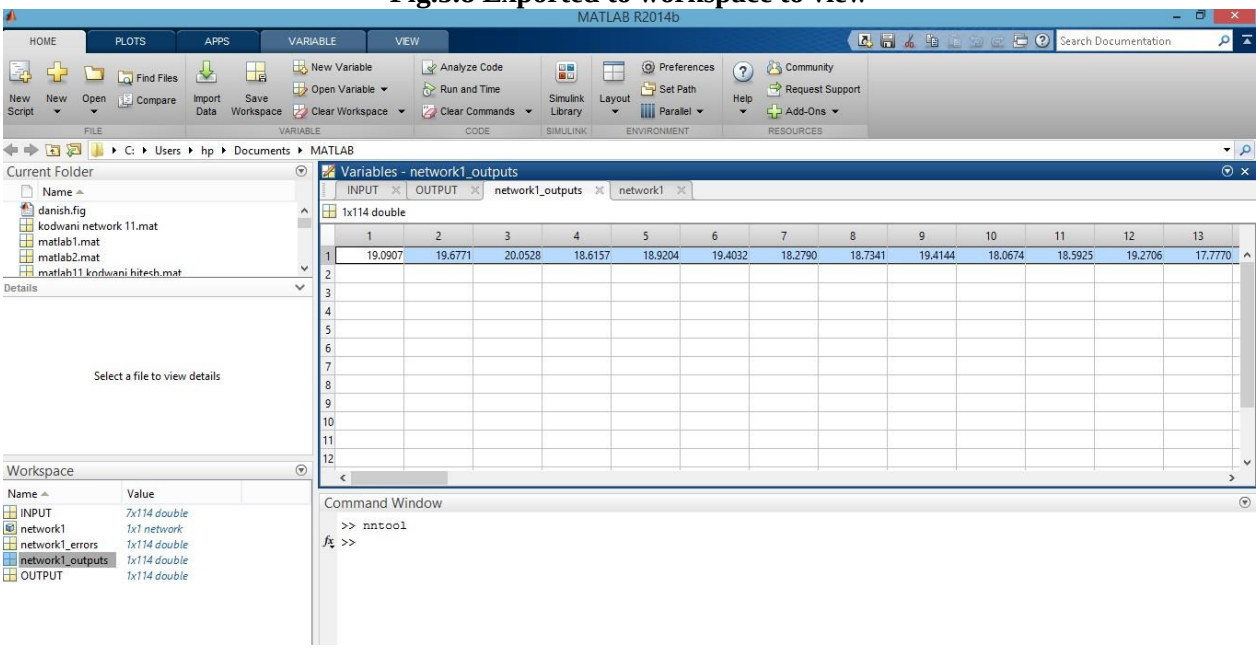


Fig.5.9 Mean Square Error (MSE)

The outputs produced by the model have been compared with the target outputs, which are the compressive strengths obtained experimentally. Generalization ability of developed network is measured by the mean square error (MSE). Fig.5.6 presents the Mean square error (MSE) for 14 epochs in all the three runs during training. It has been observed that MSE decreased after each runand the best results found at 8 epochs.

5.2 PROPOSED MODEL FOR WORKABILITY

Artificial neural network based analytical model is proposed, in which Multi Layer Feed Forward Network is utilised.

Various elements of structure are tabulated: Table-5.4

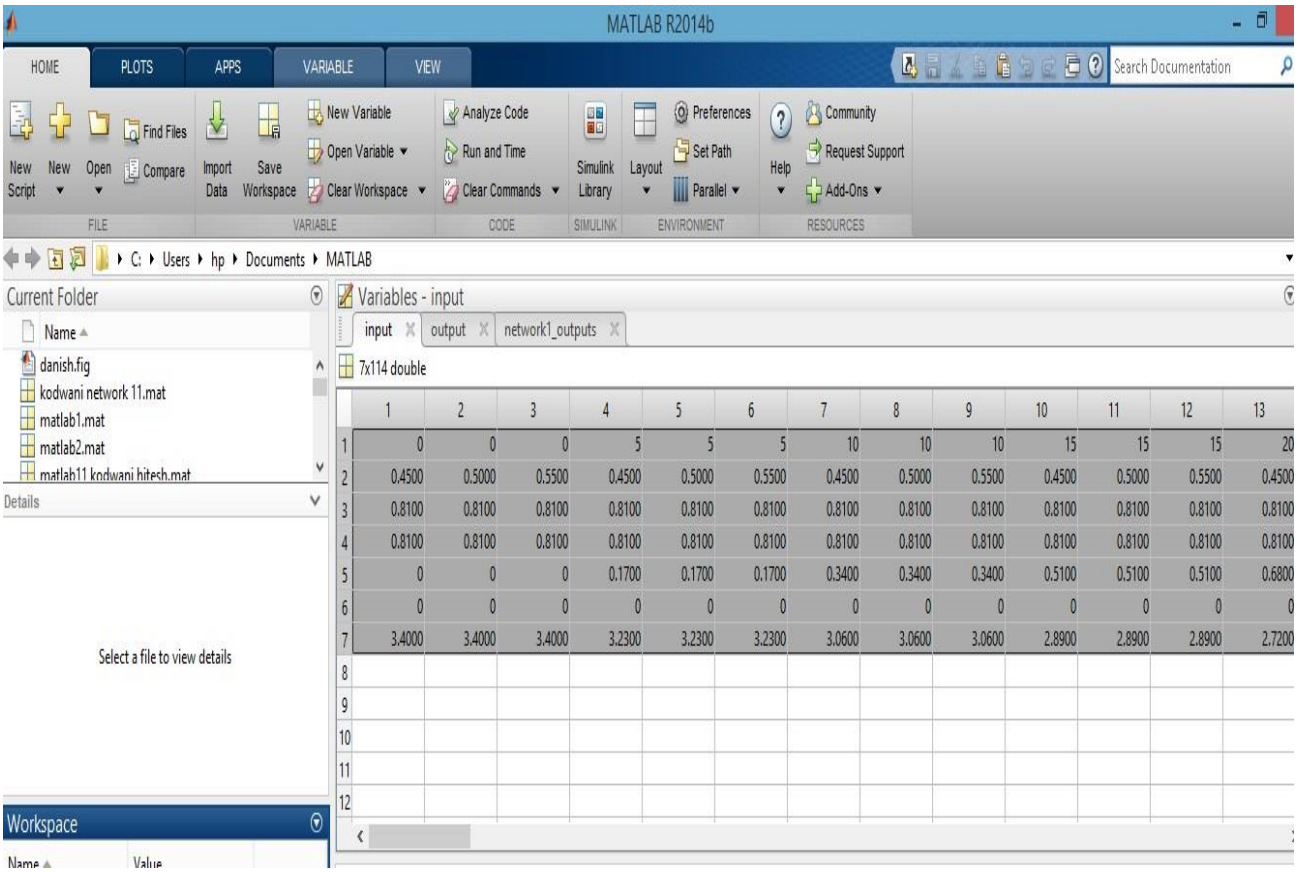
Table-5.4 Analytical model is proposed

Neural Network	**MLP**
Number of Input Variables	7
Number of Hidden Layer	2
Number of Hidden Neuron in First Hiddenlayer	20
Activation function used in first hiddenlayer	Straight line

Neural Network Input Variables used for parametric study are tabulated in Table-5.2.

PROCEDURAL STEPS FOR MODELLING

STEP 1-Matrix is formed for both input and target data in work space.



	1	2	3	4	5	6	7	8	9	10	11	12	13
1	0	0	0	5	5	5	10	10	10	15	15	15	20
2	0.4500	0.5000	0.5500	0.4500	0.5000	0.5500	0.4500	0.5000	0.5500	0.4500	0.5000	0.5500	0.4500
3	0.8100	0.8100	0.8100	0.8100	0.8100	0.8100	0.8100	0.8100	0.8100	0.8100	0.8100	0.8100	0.8100
4	0.8100	0.8100	0.8100	0.8100	0.8100	0.8100	0.8100	0.8100	0.8100	0.8100	0.8100	0.8100	0.8100
5	0	0	0	0.1700	0.1700	0.1700	0.3400	0.3400	0.3400	0.5100	0.5100	0.5100	0.6800
6	0	0	0	0	0	0	0	0	0	0	0	0	0
7	3.4000	3.4000	3.4000	3.2300	3.2300	3.2300	3.0600	3.0600	3.0600	2.8900	2.8900	2.8900	2.7200
8													
9													
10													
11													
12													

Fig.5.10 Matrix is formed

STEP 2-Data transferred to Data manager.

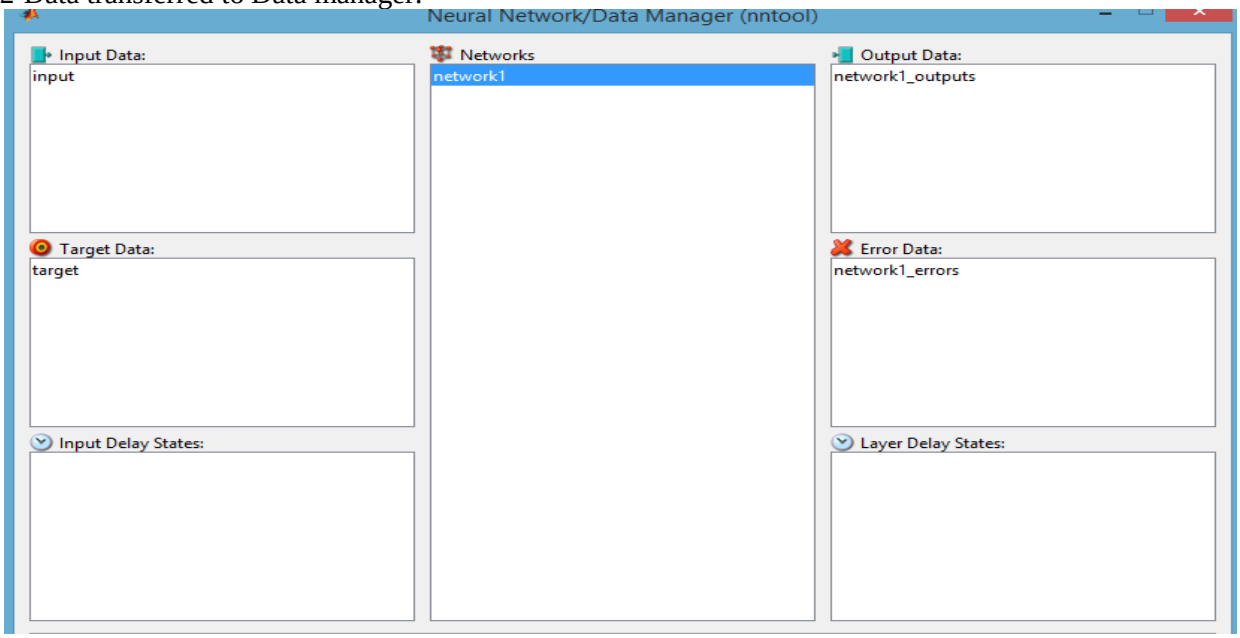


Fig.5.11 Data transferred to Data manager

STEP 3- Set network type, number of layers and neurons to be used and create network.

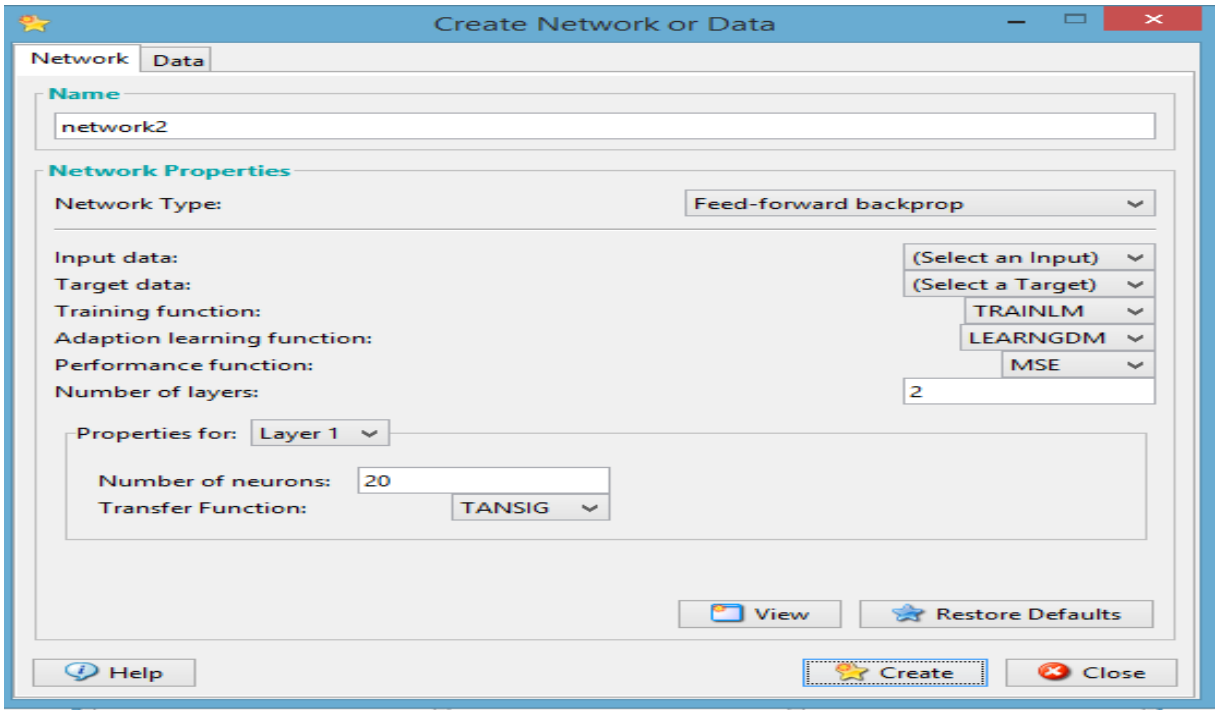


Fig.5.12 create network

STEP 4-After creating network, training is to be done.

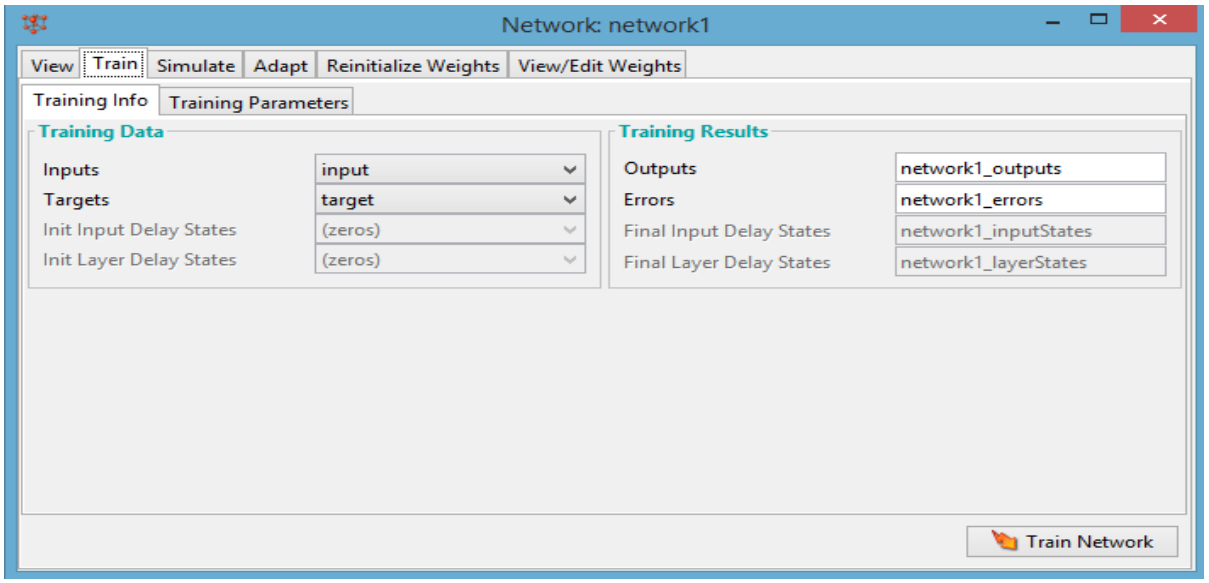


Fig.5.13 creating network

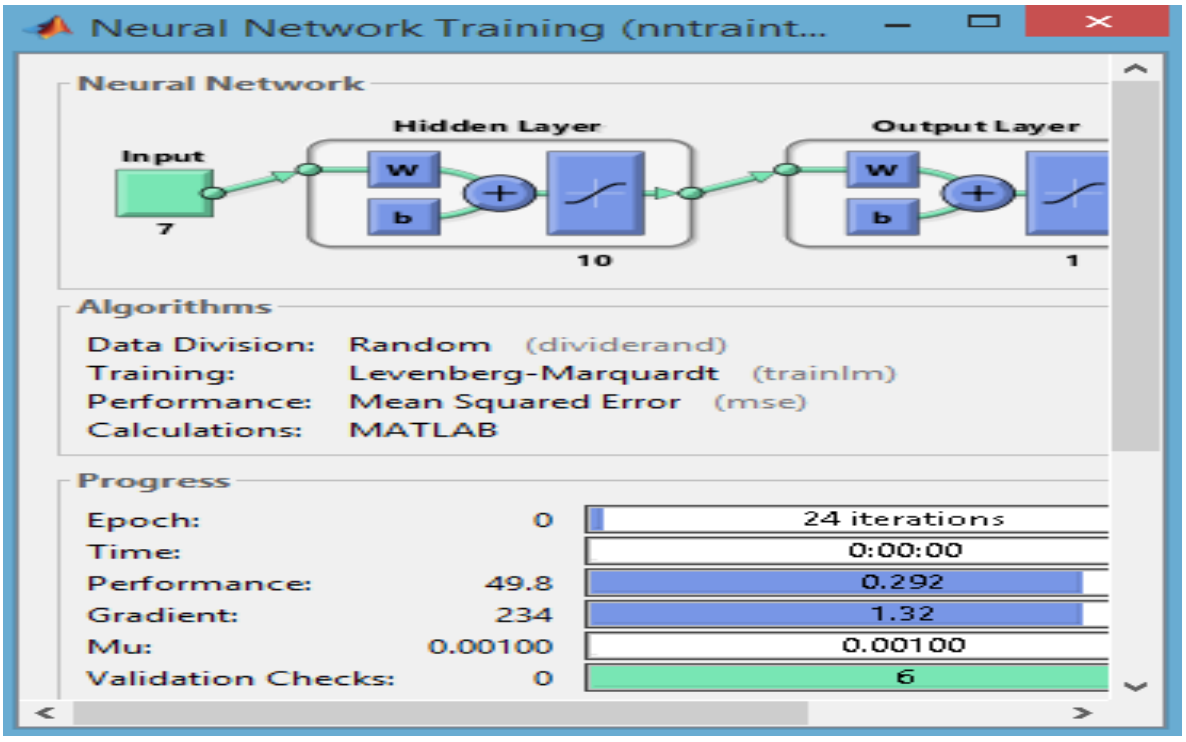


Fig.5.14 Neural Network Training

STEP 5- Finally performance graph can be obtained.

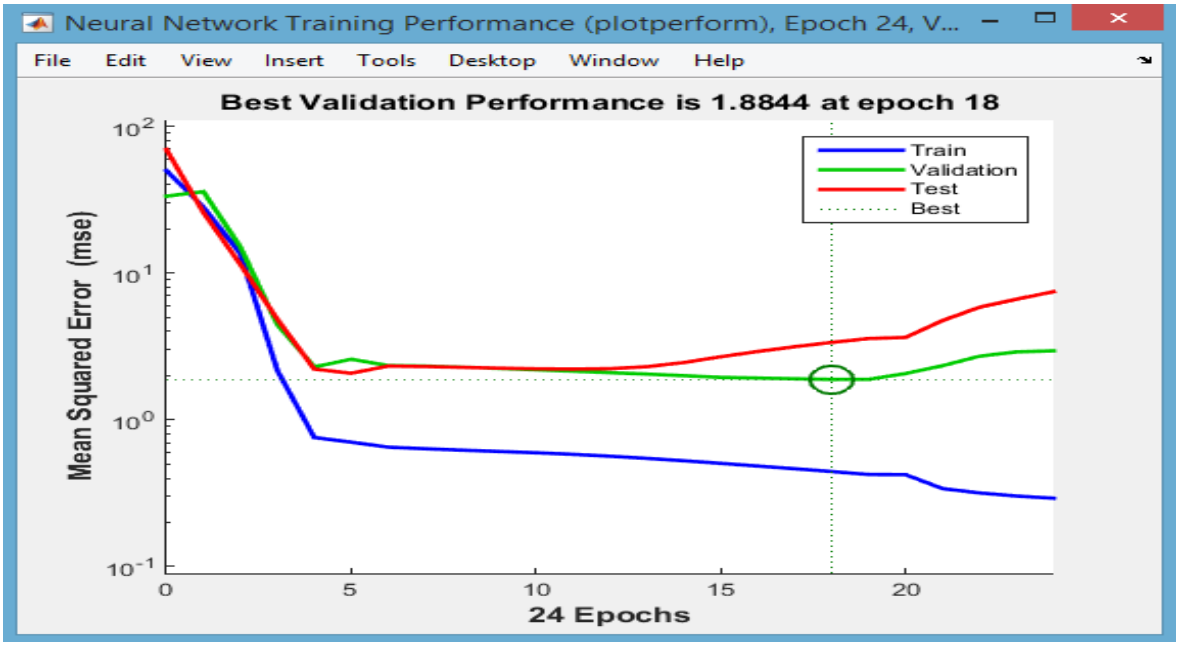


Fig.5.15 Performance graph

Fig. 5.15 and table 5.6 provide the results of all the three data set using training, testing and validation data with whole data considering value of „R" correlation coefficient. Value of „R" indicates similarity between two data series, it value ranges from -1 to +1. A larger value of „R" indicates better correlation. It has been observed from table 5.5, that value of

„R" between output from model and target value, for all the three sets of data is reaching „1"which indicates a good correlation.

STEP 6- Obtained network exported to workspace to view the predicted results and error(difference from original results)

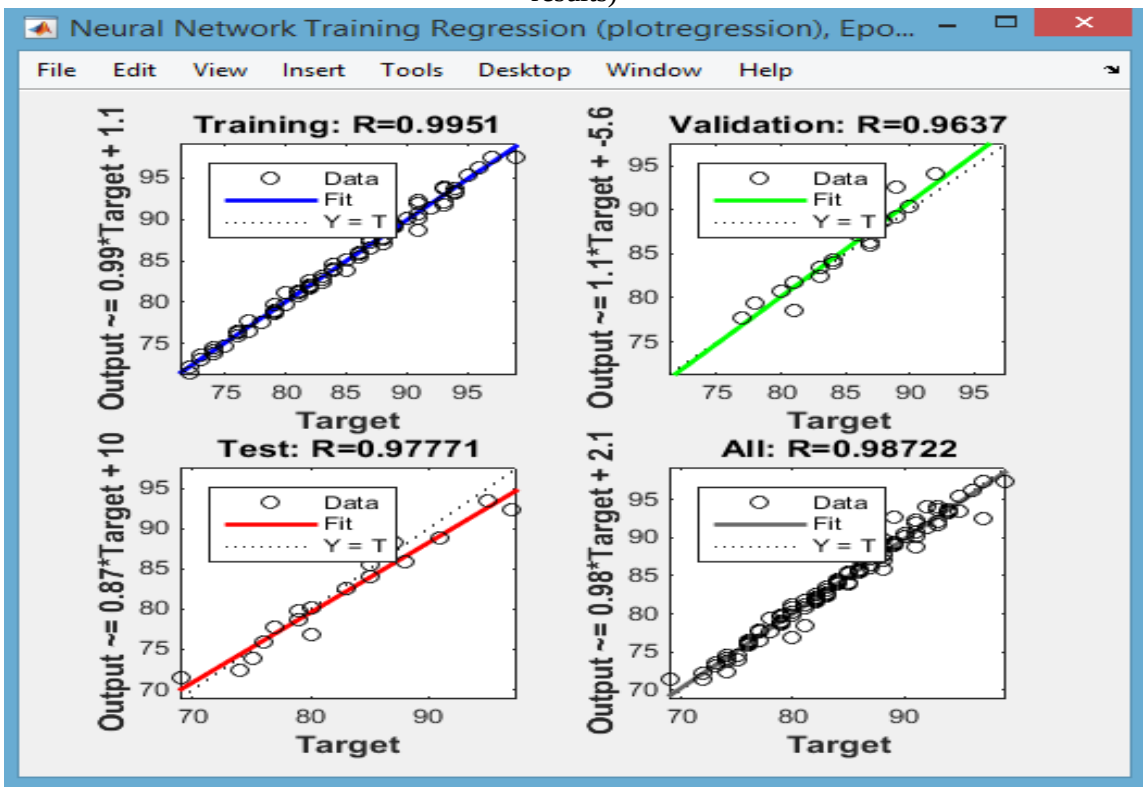


Fig.5.16 Difference from original results

Values of Regression Coefficient are tabulated in Table-5.5

Table-5.5 Values of Regression Coefficient

Data set	Value of R
Training	0.9951
Validation	0.9637
Test	0.97771
All	0.98722

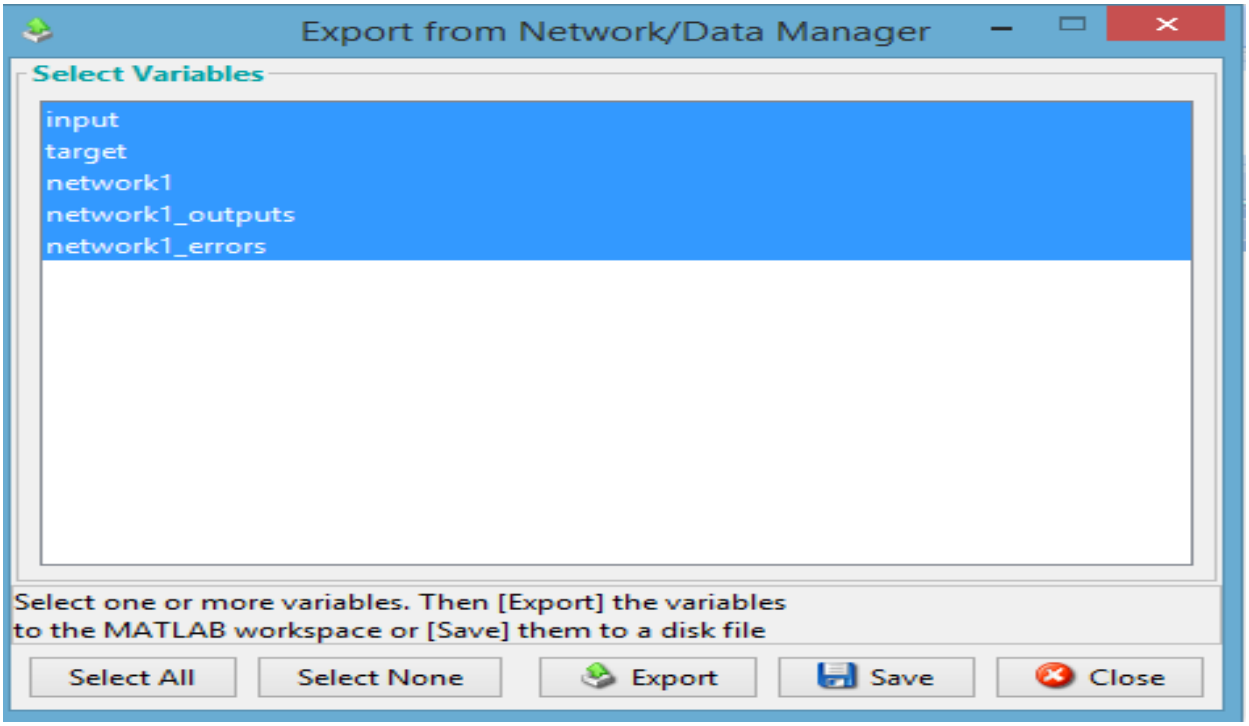


Fig.5.17 Export from Network

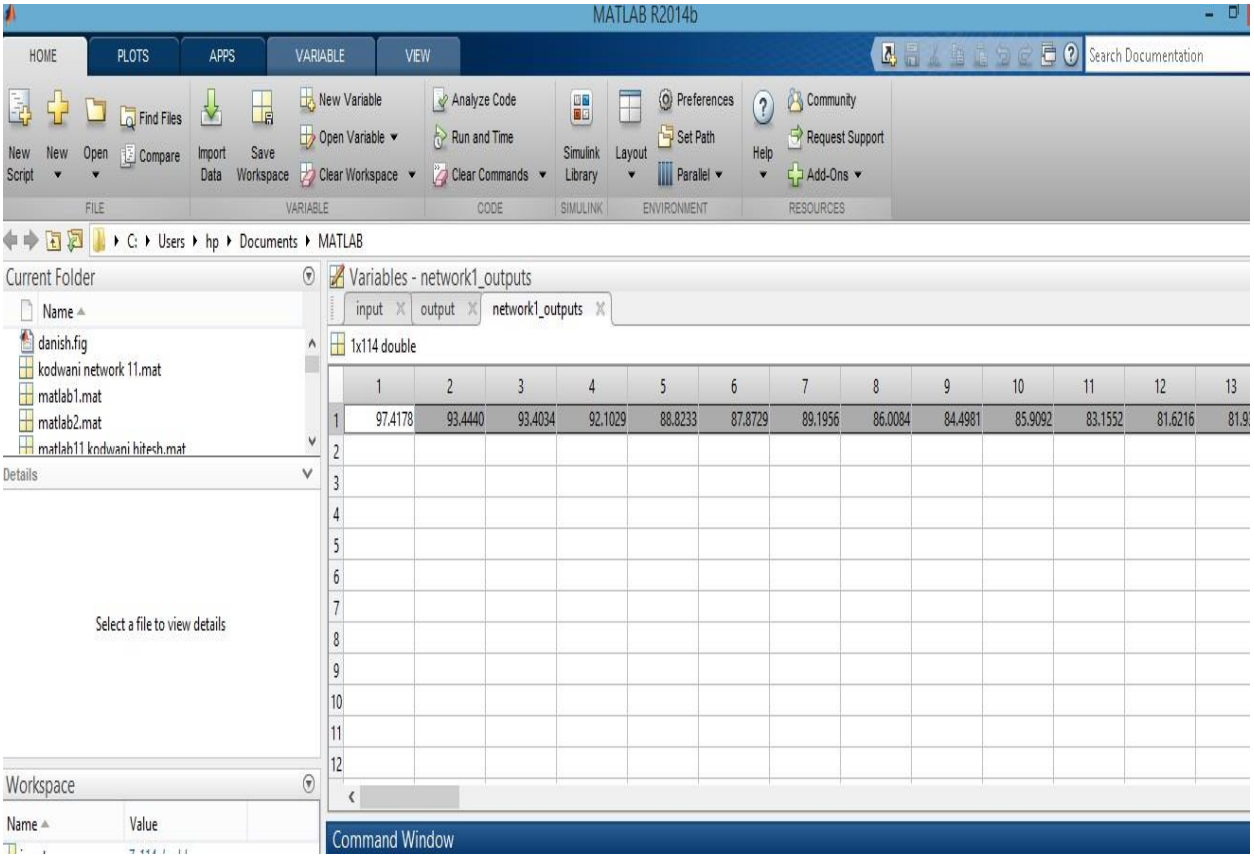


Fig.5.18 Export from Network & difference data Manager

The outputs produced by the model have been compared with the target outputs, which are the compressive strengths obtained experimentally. Generalization ability of developed network is measured by the mean square error (MSE). Fig.5.15 presents the Mean square error (MSE) for 24 epochs in all the three runs during training. It has been observed that MSE decreased after each runand the best results found at 18 epochs.

5.3 PREDICTED RESULTS

A total of 114 different experimental results are employed as a database. Total data set is divided into training set (70%), test set (15%) and validation set (15%). The predicted results are as follows:

Table 5.6- Strength Comparison

Sand/ Marble Powder (1:1)							
S. No.	**Concrete Mix**	**Compressive strength**	**Predicted Compressive strength**	**Error %**	**Slump height in mm**	**Predicted Slump in mm**	**Error %**
1	Cx1	19.2	19.09	0.57	97	97.42	-0.43
2	Cx2	19. 4	19.68	-1.44	95	93.44	1.64

3	Cx3	19.9	20.05	-0.77	94	93.4	0.63
4	Cx4	18.6	18.62	-0.08	93	92.1	0.96
5	Cx5	18.9	18.92	-0.11	91	88.82	2.39
6	Cx6	19.4	19.4	-0.02	88	87.87	0.14
7	Cx7	18.4	18.28	0.66	89	89.2	-0.22
8	Cx8	18.7	18.73	-0.18	87	86.01	1.14
9	Cx9	19.3	19.41	-0.59	84	84.5	-0.59
10	Cx10	18.1	18.07	0.18	86	85.91	0.11
11	Cx11	18.7	18.59	0.57	83	83.16	-0.19
12	Cx12	19.1	19.27	-0.89	82	81.62	0.46
13	Cx13	17.9	17.78	0.69	82	81.93	0.08

14	Cx14	18.3	18.32	-0.12	80	80.81	-1.02
15	Cx15	18.6	18.91	-1.66	77	77.85	-1.1
16	Cx16	17.6	17.54	0.36	79	78.94	0.08
17	Cx17	18.2	18.04	0.89	77	76.56	0.57
18	Cx18	18.5	18.46	0.2	74	73.81	0.26
19	Cx19	17.1	17.39	-1.69	76	76.52	-0.68
20	Cx20	17.8	17.8	-0.02	73	73.55	-0.75
21	Cx21	18	18.06	-0.31	72	72.18	-0.26
22	Cx22	19.6	19.57	0.16	92	94.06	-2.24
23	Cx23	19. 8	19.87	-0.36	90	90.17	-0.18
24	Cx24	20.3	20.23	0.36	89	89.4	-0.45

25	Cx25	19.8	19.93	-0.65	91	90.2	0.88
26	Cx26	20.1	20.21	-0.57	88	86.99	1.15
27	Cx27	20.7	20.58	0.58	84	84.1	-0.12
28	Cx28	19.9	20.02	-0.6	86	87.15	-1.34
29	Cx29	20.4	20.45	-0.23	83	82.39	0.73
30	Cx30	20.8	20.85	-0.26	81	78.48	3.11
31	Cx31	20.1	20.15	-0.23	82	82.6	-0.73
32	Cx32	20.7	20.64	0.31	77	77.73	-0.95
33	Cx33	21.1	21.05	0.26	74	74.11	-0.15
34	Cx34	20.3	20.39	-0.47	80	80.23	-0.28
35	Cx35	20.8	20.82	-0.09	76	75.86	0.18

36	Cx36	21.3	21.16	0.66	74	72.34	2.25
37	Cx37	20.7	20.68	0.12	79	78.86	0.18
38	Cx38	21.2	20.99	0.99	75	73.94	1.41
39	Cx39	21.5	21.23	1.26	72	71.37	0.88
40	Cx40	19.2	19.18	0.12	91	92.18	-1.3
41	Cx41	19. 4	19.48	-0.41	88	88.72	-0.81
42	Cx42	19.7	19.86	-0.83	87	88.31	-1.51
43	Cx43	19.3	19.33	-0.16	89	89.13	-0.15
44	Cx44	19.6	19.68	-0.4	87	86.36	0.73
45	Cx45	19.8	20.13	-1.68	84	84.24	-0.29

46	Cx46	19.5	19.64	-0.73	85	85.44	-0.52
47	Cx47	19.9	20.06	-0.81	82	81.79	0.26
48	Cx48	20.2	20.44	-1.18	80	79.76	0.3
49	Cx49	19.9	19.89	0.06	81	81.09	-0.12
50	Cx50	20.3	20.32	-0.1	77	77.75	-0.98
51	Cx51	20.6	20.64	-0.18	74	74.57	-0.77
52	Cx52	20.1	20.11	-0.04	80	76.86	3.92
53	Cx53	20.4	20.57	-0.81	75	74.65	0.47
54	Cx54	20.7	20.81	-0.54	72	72.19	-0.27
55	Cx55	20.3	20.29	0.07	77	76.52	0.62

56	Cx56	20.8	20.73	0.35	73	73.15	-0.21
57	Cx57	21.1	20.9	0.94	69	71.41	-3.49

Strength Comparison Sand/ Marble Powder (1:0.5)							
S. No.	**Concrete Mix**	**Compressive strength**	**Predicted Compressive strength**	**Error %**	**Slump height in mm**	**Predicted Slump in mm**	**Error %**
1	Cy1	19.1	19.08	0.11	99	97.4	1.61
2	Cy2	19. 3	19.47	-0.88	96	96.16	2.87
3	Cy3	19.8	19.91	-0.53	94	93.73	2.36
4	Cy4	18.4	18.57	-0.91	97	92.4	1.7
5	Cy5	18.6	18.82	-1.17	93	91.71	5.45
6	Cy6	19.1	19.25	-0.8	91	88.76	4.56
7	Cy7	18.1	18.27	-0.92	92	91.35	-0.38
8	Cy8	18.4	18.61	-1.15	89	89.02	3.24
9	Cy9	19.1	19.24	-0.73	87	87.22	2
10	Cy10	18.1	18.07	0.17	89	89.04	-2.35
11	Cy11	18.5	18.44	0.32	87	86.51	2.79
12	Cy12	19.8	19.07	3.68	84	83.9	3.56

13	Cy13	17.8	17.75	0.3	85	85.17	-1.39
14	Cy14	18.1	18.12	-0.09	82	82.07	3.45
15	Cy15	18.2	18.65	-2.5	79	79.67	2.84
16	Cy16	17.3	17.48	-1.06	83	82.47	-4.4
17	Cy17	18	17.79	1.19	79	79.76	3.9
18	Cy18	18.2	18.16	0.21	78	77.64	1.72
19	Cy19	17	17.33	-1.92	81	81.19	-4.09
20	Cy20	17.4	17.53	-0.76	79	78.66	2.89
21	Cy21	17.8	17.75	0.3	76	75.88	3.95
22	Cy22	19.2	19.3	-0.5	95	95.37	-25.49
23	Cy23	19. 4	19.49	-0.46	93	93.94	1.11
24	Cy24	20	19.91	0.45	90	90.47	2.72
25	Cy25	19.5	19.5	0.02	94	93.18	-3.53
26	Cy26	19.8	19.66	0.7	91	90.65	3.56
27	Cy27	20.1	20.13	-0.13	88	87.64	3.69
28	Cy28	19.4	19.49	-0.48	89	89.22	-1.39
29	Cy29	19.9	19.81	0.47	86	85.78	3.62
30	Cy30	20.2	20.28	-0.37	85	84.01	2.31
31	Cy31	19.9	19.58	1.63	88	85.82	-0.96
32	Cy32	20.3	20.05	1.25	85	83.86	4.7

33	Cy33	19.1	20.43	-6.98	83	82.37	3.09
34	Cy34	19.4	19.9	-2.55	83	82.79	0.25
35	Cy35	20.1	20.38	-1.39	80	81.21	2.16
36	Cy36	20.4	20.62	-1.06	78	79.48	0.65
37	Cy37	20.7	20.36	1.66	81	81.13	-4.02
38	Cy38	20.9	20.72	0.85	79	78.7	2.84
39	Cy39	21.5	20.8	3.24	76	76.02	3.78
40	Cy40	19	18.96	0.22	93	93.68	-23.27
41	Cy41	19.3	19.21	0.47	89	92.64	0.38
42	Cy42	19.5	19.61	-0.58	87	89.42	-0.48
43	Cy43	19.1	18.99	0.6	91	91.91	-5.64
44	Cy44	19.4	19.32	0.4	88	89.65	1.48
45	Cy45	19.7	19.81	-0.54	87	87.6	0.45
46	Cy46	19.3	19.27	0.15	88	88.73	-1.99
47	Cy47	19.4	19.59	-0.99	86	85.75	2.55
48	Cy48	19.8	19.98	-0.93	83	83.52	2.88
49	Cy49	19.6	19.59	0.06	86	85.51	-3.03
50	Cy50	20.1	19.84	1.29	83	83.19	3.27
51	Cy51	20.4	20.08	1.55	81	80.78	2.67
52	Cy52	19.8	19.87	-0.34	84	84.04	-3.76

53	Cy53	20.1	20.07	0.17	81	81.24	3.28
54	Cy54	20.3	20.16	0.71	79	78.64	2.91
55	Cy55	19.7	20.13	-2.19	81	81.72	-3.44
56	Cy56	20.1	20.26	-0.82	79	78.95	2.52
57	Cy57	20.4	20.23	0.86	76	76.28	3.44

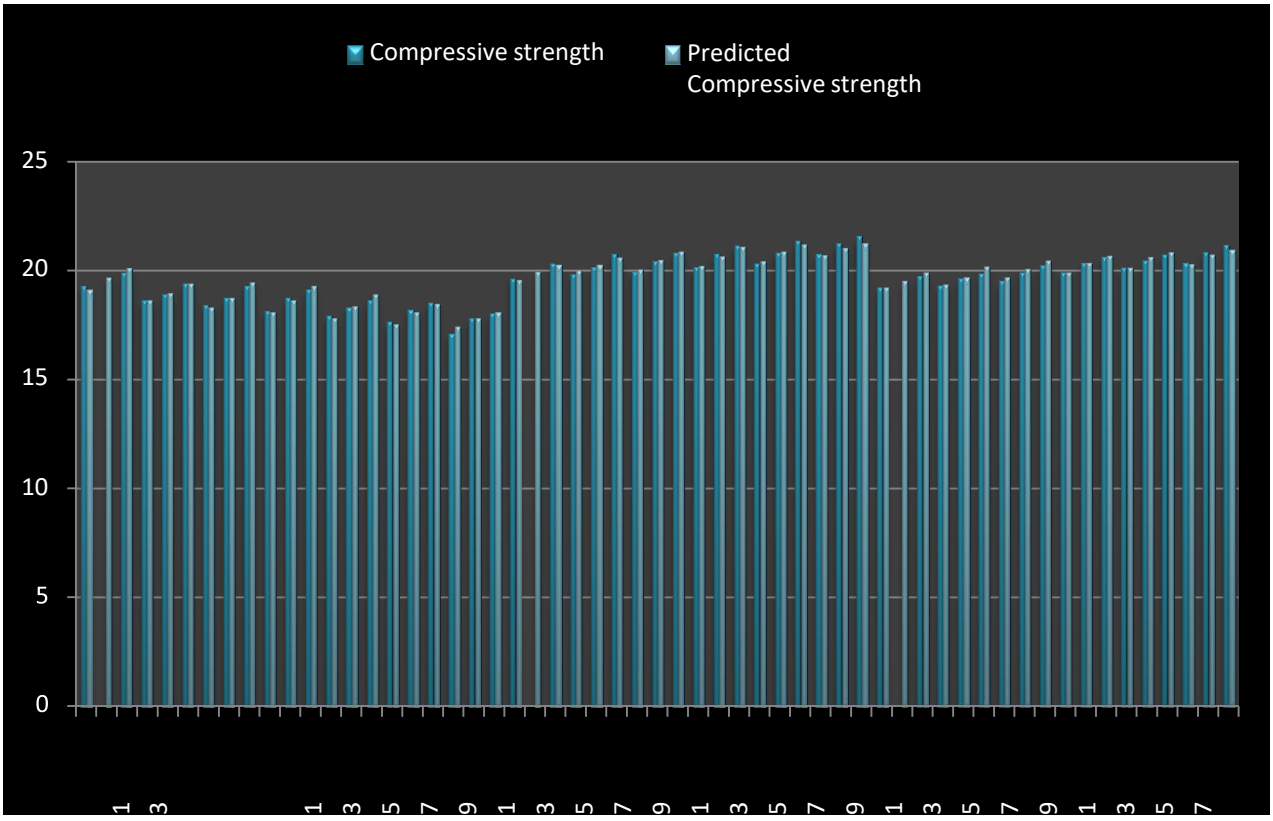


Fig. 5.19. Strength comparison (Sand/ Marble Powder (1:1)

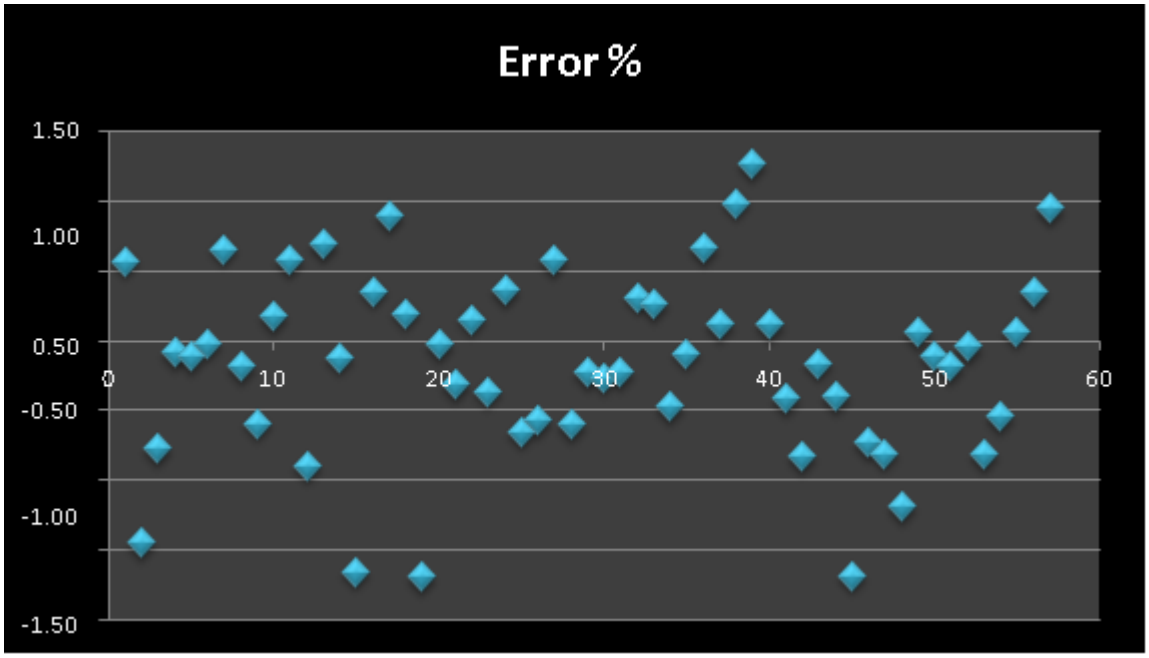


Fig. 5.20. Error between actual and predicted strength (Sand/ Marble Powder (1:1)

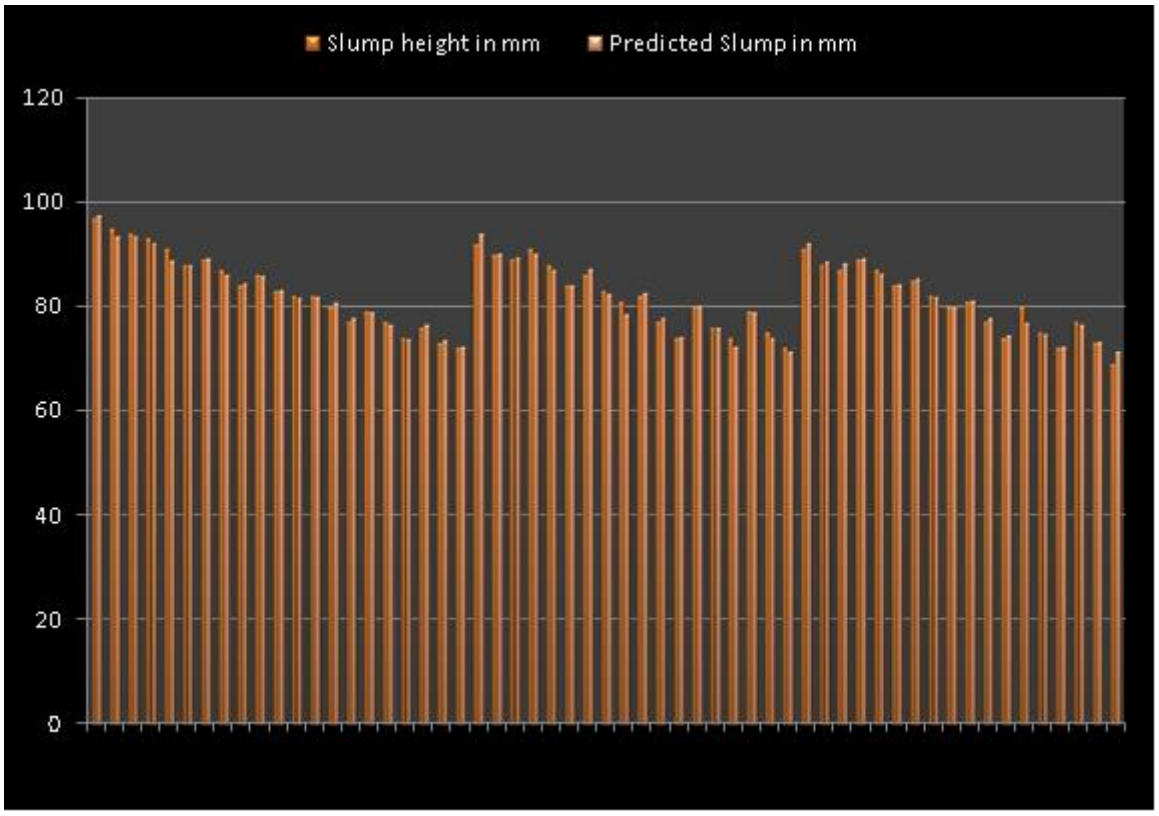


Fig. 5.21. Slump comparison (Sand/ Marble Powder (1:1)

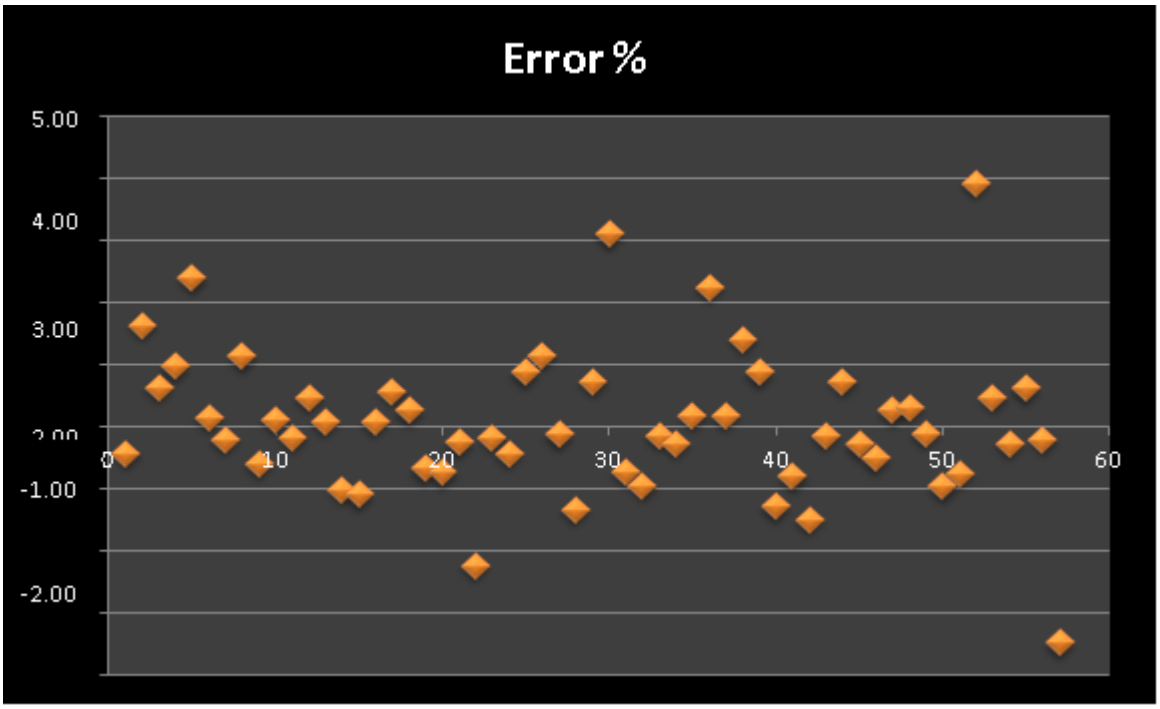


Fig. 5.22. Error between actual and predicted Slump (Sand/ Marble Powder (1:1)

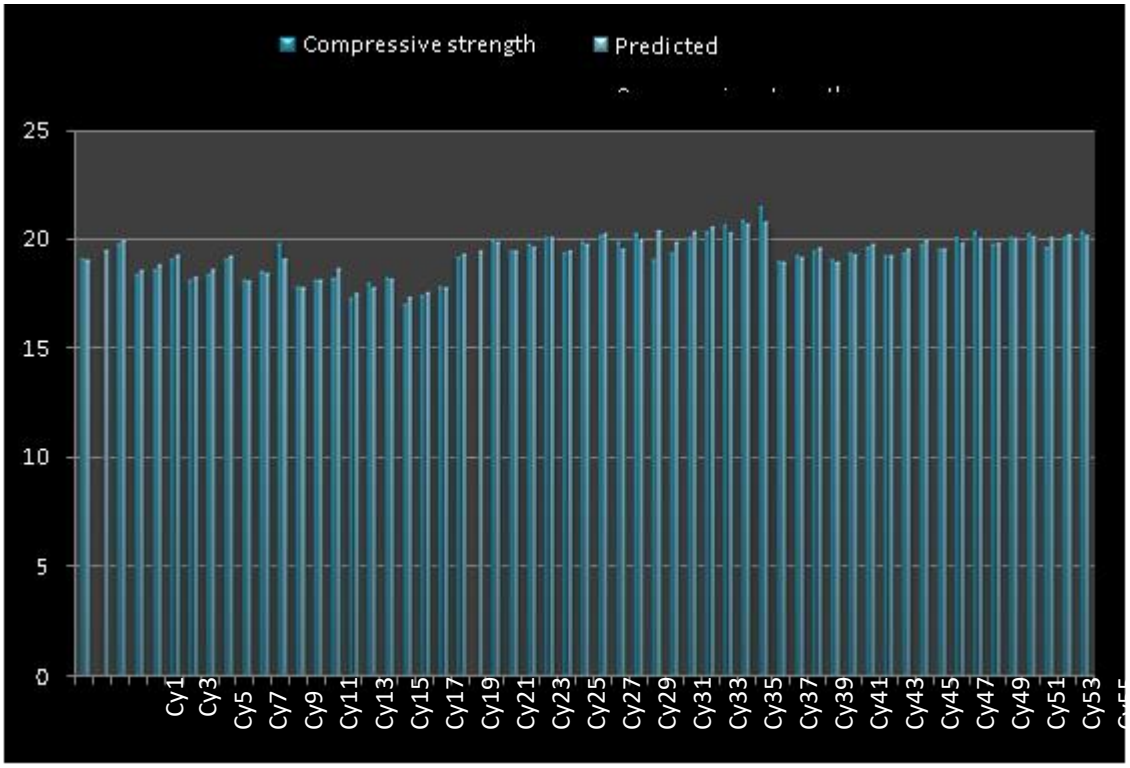


Fig. 5.23. Strength comparison (Sand/ Marble Powder (1:0.5)

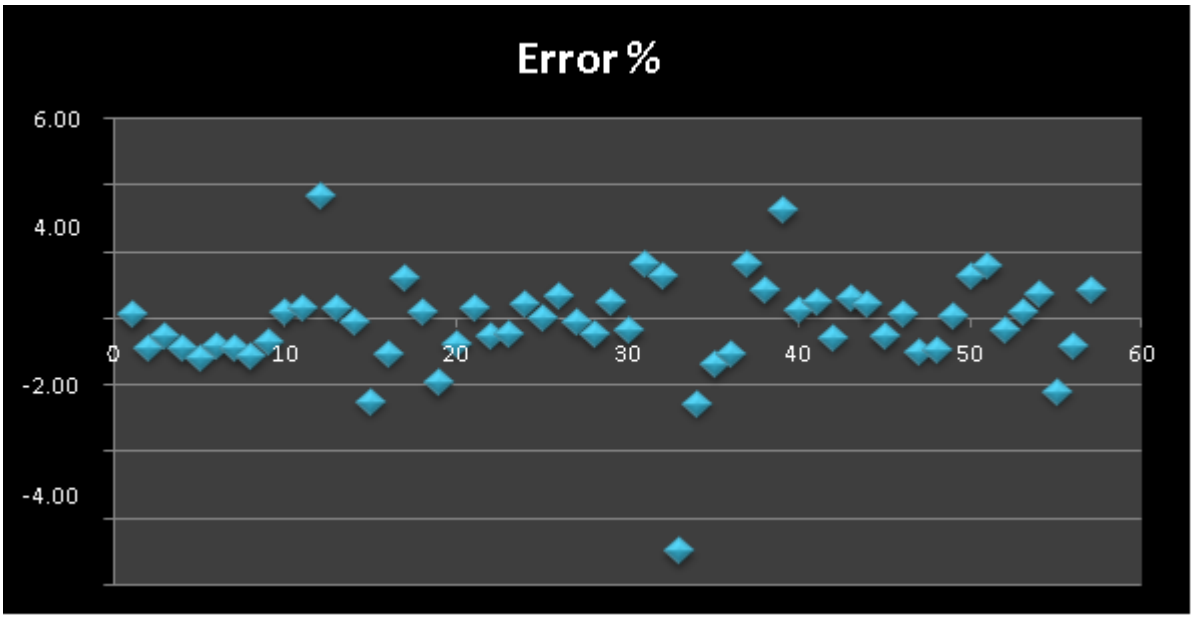


Fig. 5.24. Error between actual and predicted strength (Sand/ Marble Powder (1:0.5)

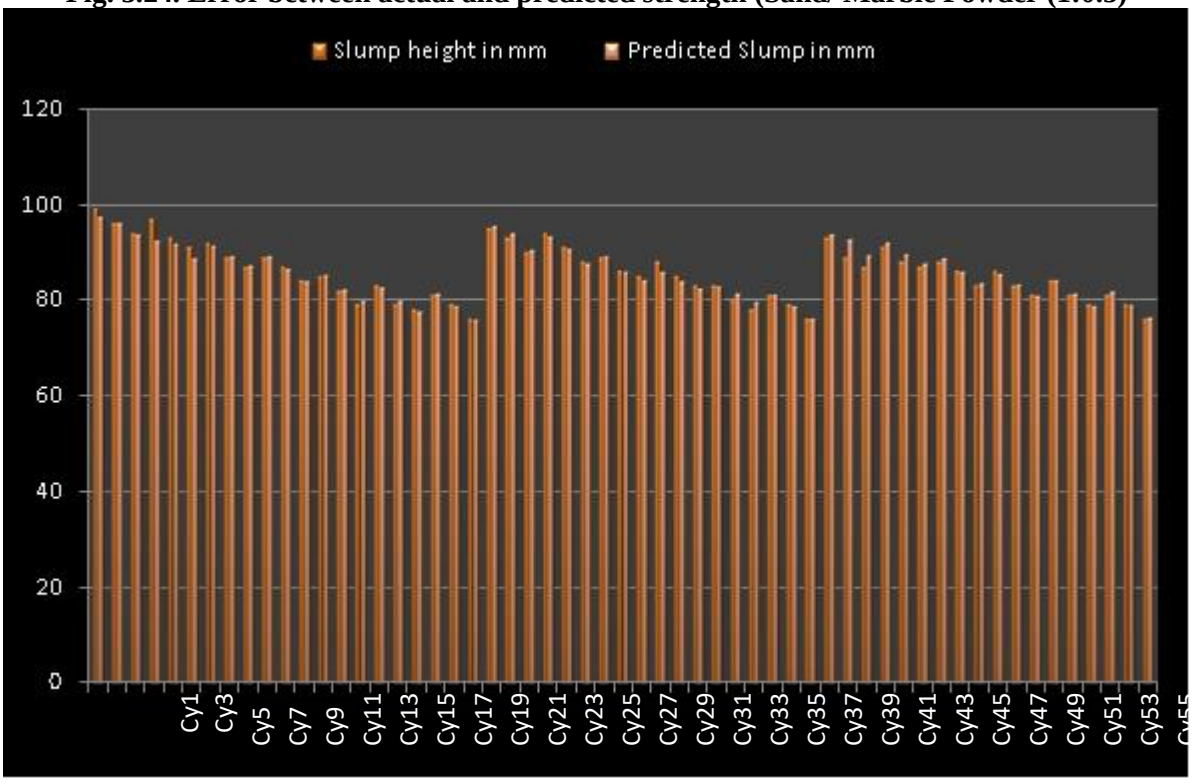


Fig. 5.25. Slump comparison (Sand/ Marble Powder (1:0.5)

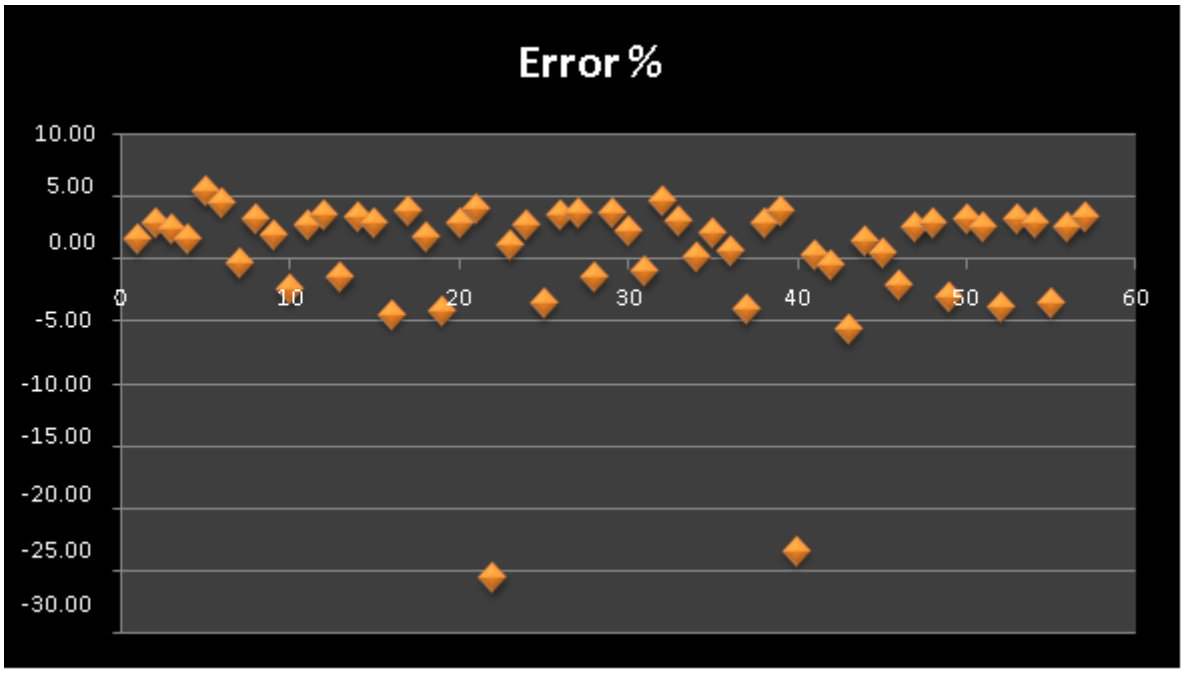


Fig. 5.26. Error between actual and predicted Slump (Sand/ Marble Powder (1:0:5)

CHAPTER 6 CONCLUSIONS

6.1 Conclusions

An experimental study has been performed to evaluate the combined effect of using partially Flaky aggregates, steel slag and marble powder over the compressive strength and workability of concrete. Results of performed experiments have been used to develop an ANN model. Following are the conclusions of the experimental works –

1. It has been observed that properties of concrete mixes formed by replacing normal aggregate with flaky aggregate in small proportions is almost equivalent with the values of normal aggregate.
2. With the increase in percentage of flaky aggregate and steel slag values of compressive strength and slump cone reduces.
3. When flaky aggregate and steel slag applied together moderate value of both compressive strength and slump values are obtained.
4. With the increase in water cement ratio values of compressive strength increases and slump cone reduces.
5. Additional effect of marble powder over the variation of flaky aggregates and steel has been determined by sand with glass powder in different proportions, 1:1 and 1:0.5 for eachvariation of flaky aggregate.
6. Increase in Proportion of Marble powder reduces the compressive strength for a flaky aggregate proportion.
7. Increase in percentage of glass powder reduces the slump value for a flaky aggregate proportion.
8. Hence, it has been observed that replacing normal aggregate with flaky aggregates reduces the workability of concrete, and after 40% replacement concrete becomes very poor in terms of workability and strength.
9. Using laboratory results an ANN model has been developed to determine the compressive strength and slump values based on Percentage replacement of coarse aggregate, w/c ration, proportion of sand, marble powder, flaky aggregate and steel slag.
10. A total of 114 different experimental results are employed as a database. Total data set is divided into training set (70%), test set (15%) and validation set (15%)
11. It has been observed from table 5.3, regression coefficient between output from model and experimental values, is almost „1“ indicating a good correlation.

6.2 Future Scope

1. For determining the suitability and usefulness of waste materials in data in terms of properties andtheir variation are required.

2. Several other materials are required to test as replacement for different sets of properties.

3. It has been vital to observe changes in characteristics of concrete for judging the suitable materialsamong the tested materials as a good replacement of cement.

References

[1.] Adom-Asamoah M, Afrifa R O "Investigation On The Flexural Behaviour Of Reinforced Concrete Beams Using Phyllite Aggregates From Mining Waste" Materials & Design, 32(10), 5132- 5140

[2.] Agrawal P., Gupta Y.P., Bal S. "Effect Of Fineness Of Sand On The Cost And Properties Of Concrete" Nbmcw October 2007

[3.] Akbulut, H., & Gürer, C. (2007). Use of aggregates produced from marble quarry waste in asphalt pavements. Building and Environment, 42(5), 1921-1930.

[4.] Altaf et al. (2013) "Suitability Of Waste Glass Powder As A Partial Replacement Of Cement In Fibre Reinforced Concrete" Project Report, A.I.A.R. KALSEKAR POLYTECHNIC New Panvel 410 206, Navi Mumbai.

[5.] Bant Singh, Dr, and Srijit Biswas. "Upgrading Properties of Aggregates in Flexible Pavements with e-Control."International Journal of Scientific & Engineering Research, Volume 4, Issue 9, September-2013 2543 ISSN 2229-5518

[6.] Chen J., Lin K.Y., Chang M.K. "Influence Of Coarse Aggregate Shape On The Strength Of Asphalt Concrete Mixtures" Journal Of The Eastern Asia Society For Transportation Studies, Vol. 6, Pp. 1062 - 1075, 2005

[7.] Hamzah M O, Puzi M A A, Azizli K A M " Properties Of Geometrically Cubical AggregatesAnd Its Mixture Design" Ijrras 3 (3) ● June 2010

[8.] Jain A K, Chouhan J S (2011) "Effect of Shape of Aggregate on compressive strength And Permeability Properties of Pervious Concrete" International Journal of Advanced Engineering Research and Studies E-ISSN2249 – 8974

[9.] Jarkasi, Mohd. Daud (2013) Influence Of Aggregate Flakiness On Marshall Properties For Asphaltic Concrete (Ac14) Mixture. M. Tech. thesis, Universiti Teknologi Malaysia, Faculty Of Civil Engineering.

[10.] Kandekar S B, Mehetre A J, Auti V A "Strength Of Concrete Containing Different Types Of Fine Aggregate" International Journal Of Scientific & Engineering Research Volume 3, Issue 9,September-2012

[11.] Kaplan M F "The Effects Of The Properties Of Coarse Aggregates On The Workability Of Concrete" Magazine Of Concrete Research, Volume 10, Issue 29, 01 August 1958 , Pages 63 –74

[12.] Khatib J.M., Negim E.M., Sohl H.S., ChilesheN. "Glass Powder Utilisation in Concrete Production" European Journal of Applied Sciences 4 (4): 173-176, 2012.

[13.] M. N. Bajad**,** C. D. Modhera**,** A. K. Desai "Resistance of Concrete Containing Waste Glass Powder against M_gSO_4 Attack" NMBCW MAY 2012

[14.] Meena Ankur and Singh Randheer (2012) "Comparative Study of Waste Glass Powder as Pozzolanic Material in Concrete" B. Tech thesis, NIT Rourkela.

[15.] Muhit, I. B., S. Haque, And Md. Rabiul Alam. "Influence Of Crushed Coarse Aggregates On Properties Of Concrete." American Journal Of Civil Engineering And Architecture 1, No. 5 (2013): 103-106.

[16.] Patil D.M., Sangle KK. "Experimental Investigation of Waste Glass Powder as Partial Replacement of Cement in Concrete" International Journal of Advanced Technology in Civil Engineering, ISSN: 2231 –5721, Volume-2, Issue-1, 2013.

[17.] Polat, Rýza, et al. "The correlation between aggregate shape and compressive strength of concrete: digital image processing approach."International Journal of Structural and Civil Engineering Research (2013): 1-19.

[18.] Ponnada M R (2014) "Combined Effect Of Flaky And Elongated Aggregates On Strength And

Workability Of Concrete" Int. J. Of Structural Engineering, 2014 Vol.5, No.4, Pp.314 – 325
[19.] Saikia, N., & de Brito, J. (2012). Use of plastic waste as aggregate in cement mortar and concrete preparation: A review. Construction and Building Materials, 34, 385-401.
[20.] Shayan and Xu (2006) "Performance of glass powder as a pozzolanic material in concrete: A field trial on concrete slabs" Cement and Concrete Research 36 (2006) 457–468.
[21.] Shetty, M.S. (2003 Edition) Concrete Technology: Theory And Practice, S. Chand & Company Ltd, India.
[22.] Siswosoebrotho B I, Soedirdjo T L, Ginting K "Workability And Resilient Modulus Of Asphalt Concrete Mixtures Containing Flaky Ggregates Shape" Journal Of The Eastern Asia Society For Transportation Studies, Vol. 6, Pp. 1302 - 1312, 2005
[23.] Taha B., Nounu G. "Utilizing waste recycled glass as sand/cement replacement in concrete"J. Mat. Civil. Engg., 21(12), 709-721.
[24.] Tan K.W., Du H. "Use of waste glass as sand in mortar: part I- fresh, mechanical and durability properties". Cem. Conc. Comp., 35, 109-117.
[25.] Vasudevan G., Pillat SGK (2013) "Performance of Using Waste Glass Powder In Concrete As Replacement Of Cement" American Journal of Engineering Research, Volume -02, Issue-12, pp- 175-181.
[26.] Vyawahare M R, Modani P O "Improvement In Workability And Strength Of Concrete With Flaky And Elongated Aggregates" 34thconference On Our World In Concrete & Structures: 16 - 18 August 2009, Singapore
[27.] Westerholm, M., Lagerblad, B., Silfwerbrand, J., & Forssberg, E. (2008). Influence of fine aggregate characteristics on the rheological properties of mortars. Cement and Concrete Composites, 30(4), 274-282.
[28.] Zega, C. J., Villagran-Zaccardi, Y. A., & Di Maio, A. A. (2010). Effect of natural coarse aggregate type on the physical and mechanical properties of recycled coarse aggregates. Materials and Structures, 43(1-2), 195-202.