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The Wastes Utility in Concrete

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ABSTRACT: The Marble Slurry Wastes (MSW) produced by marble industry is left unattended in the environment which causes serious environmental problems. In order to evaluate its potential usage in normal 1:2:4 concrete, this study was designed, where the partial replacement of cement with MSW was examined. Replacement of cement with MSW from 0 to 100%, and also its usage as an additive material 10% and 20% by weight of cement were the main objectives of this study. Various laboratory tests, like compressive strength test, splitting tensile test and slump test were conducted by using local available MSW. The primary chemical composition of the MSW indicated that it contains high contents, nearly 97% of lime (CaO). The laboratory results show that cement in structural concrete can be replaced by MSW up to 7% safely. The compressive and splitting tensile strength of concrete was observed to be increased by 15% and 6% by the addition of 10% MSW. A similarly increase in strength was also observed by adding the 20% of MSW additionally to the normal 1:2:4 concrete. However, by the addition of MSW in concrete, its slump strength i.e., its workability is found to be reduced.

Key words: Marble powder, Compressive strength, Tensile strength, Slump

INTRODUCTION

Marble and stone waste industry has grown significantly in the last decades with the privatization trends in early 1990's. Stone waste is highly capable of polluting our environment due to its alkaline nature and porosity. The manufacturing and processing techniques impose serious health threats to the surroundings due to the vast disposal of Marble Slurry Wastes (MSW). The MSW is basically generated as a by-product during cutting and processing of marble which is approximately in the range of 20% of the total marble handled. The marble cutting plants dump the waste in any nearby pit or vacant spaces or leave it unattended near their unit although notified areas have been marked for dumping. This leads to serious environmental hazards and health problems. The dust becomes airborne after drying up and may cause serious health problems. This also may lead to contamination of the underground water reserves (Bacarji *et al*., 2013, Ali *et al*., 2014). Waste products are disposed of as soil conditioners or land fill. However, there might be reusing or recycling alternatives that should be investigated and eventually implemented. Numerous uses of waste marble powder have been introduced, which includes use in tiles manufacturing, concrete mixes, sub-grade fill, and modified binder (Kursat and Ragip 2009, Omar *et al*., 2012, Gonzalo *et al*., 2013). Pakistan is blessed with immense natural mineral resources. Nature has gifted Pakistan with sufficient wealth of marble, recrystalized lime stone, fossil ferrous limestone, dolomite and granite. Years of neglect to improve the technology in marble industry, outdated extraction methods and lack of modern manufacturing facilities have lead to inefficient utilization of this resource. Though, the extraction of marble has increased 155-folds from 3,000 tons in 1959-60 to 467,000 tons in 1994-95 (Hanifi *et al*., 2008, Khalil *et al*., 2013). Extraction and export in the last few years show a declining trend for the industry which contributed a negligible 0.13 per cent to the overall exports in 1995-96. Furthermore, the lack of quality control has resulted in wide variation in export prices 12,719 metric tons of marble and stone exports fetched \$2.285 million in 1993-94 while over seven-fold increase in the quantity in 1994-95 depicted only a 50 per cent increase in the value in 1994-95 (Valeria *et al*., 2010, Bilgin *et al.*, 2012). Since, there is rapid growth observed in the marble industry, which consequently

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increases the bulk of MSW being produced by it; hence, this study was particular design to investigate the usage of MSW in construction, particular in the in concrete as a partial replacement with cement, and as in additive, by analyzing its engineering properties.

MATERIALS & METHODS

The study was conducted in three phases. In the 1st phase 12 mixes were prepared in which cement was replaced with different percentages (0% 5% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%) of marble slurry. In 2nd phase four mixes were prepared and cement was replaced by 6%7%8%9% to find out the maximum replacement. And in the phase 3rd two mixes were prepared with 10% and 20% marble slurry as additive by weight of cement. The normal concrete mix ratio, 1:2:4 was used throughout of this study.The engineering properties of the concrete were measured in terms of its compressive strength, indirect tensile (splitting tensile) and slump test. The chemical composition of marble slurry was also studied by XRF (X-Ray Fluorescence) Test prior to its usage in the study, as shown in the Table 1. Test specimens were prepared from available local materials. These include natural siliceous sand, marble slurry from local area (Village Barabanda Nowsehera KPK, Pakistan), Ordinary Portland Cement OPC and tap water. Testing of these materials was carried out in accordance to the ASTM Standard Specifications (Osman *et al*., 2012, Gamerio *et al*., 2014). The various physical and chemical properties of the MSW used in the study are shown in the Table 2. Whereas, its particle size distribution is also shown in the Table 3. A normal concrete mix of 1:2:4 was prepared. The course and fine aggregate were first mixed in dry state until the mixture become homogenous. All binder materials i.e. cement and marble powder was added to the dry mixture, and mixing continued until the mixture became homogenous. A standard mix design by absolute volume method was made which was kept constant throughout the experiments. The MSW was first dried in open air and then oven dried for 24hrs to remove all its moisture content. After that it was crushed so that it could attain a uniform texture free from lumps and could easily mix with the cement and concrete to give a uniform composition throughout the mix (Ali, 2011). Compression Test at 7, 14 and 28 days was carried out on 150 × 300 mm cylinders and Splitting Test at 28 days was carried out on 150 × 300 mm cylinder. All the test specimens were remolded after 24 hrs and then stored under water in curing tanks with room temperature (12±2°C) (Huseyin *et al*., 2010, Pawan *et al*., 2013).

Table 1. Chemical composition of MSW used in the study

Elements	Percentage Composition
Mg	1.2177
Si	0.3347
S	0.0769
Ca	97.7820
Fe	0.4093
Sr	0.0824
Pb	0.0970

RESULTS & DISCUSSION

The Figs 1 shows the 7th day, 14th day and 28th day compressive strength of concrete with partial replacement of cement with MSW, respectively. The 7-Days results show that the Sample 1 with 100% cement; gives more than 2000psi of compressive strength. A gradual drop in the compressive strength of concrete was observed with the percentage replacement of cement with MSW throughout in the study. As shown, the compressive strength was found to be less than 500psi for the samples with more than 50% of MSW. However, the samples with 5% 6% 7% 8% 9% and 10%

Table 2.Physical and chemical properties of the MSW used in the study (Unpublished data)

Bulk density	1.3-1.5gm/cm^3
Specific gravity	2.83-2.87
Density	1.96 gm/cm^3
Moisture content	0.2-0.40%
Modulus of rupture	21-26 MPa
Tensile strength	23-25 MPa
Compressive strength	77-96 MPa
Water absorption# 2 hours	0.15-0.40%
Fire retarding tendency	Self extinguishing
Exposure to boiling water	No change in dimensions
Chemical action	Appears chemically inactive

Table 3. Particle size distribution of MSW used in the study (Unpublished data)

Particle size (mm)	Percentage finer by volume
363.1	100
193-205.8	90
130-140	80
81-94.7	70
54.5-62.51	60
37.5-43.1	50
23.9-28.1	40
14.24-15.2	30
5.9-7.15	20
1.23-1.69	10
0.321	0.00

MSW showed more than 1500psi of compressive strength. Refer to the 14-Days results, it was observed that samples with 0% 5% 6% 7% 8% 9% and 10% of MSW gives compressive strength between 2500-2000psi respectively, whereas, that with more than 60% of MSW gives less than 500psi of compressive strength. And those with 20% to 50% replacement of cement with MSW were found to have compressive strength greater than 2000psi and 1000psi, respectively. Also the results of 28-Days compressive strength indicates that the samples with 0% 5% 6% and 7% replacement of cement with MSW have a compressive strength above 3000psi, whereas that with 8% 9% 10% and 20% of MSW gives compressive strength between 2500-3000psi. And the samples that have more than 60% of cement replacement with MSW give a compressive strength below 1000psi. Based on the results of 7th, 14th and 28th day compressive strength, the optimum and permissible usage sample percentage replacement of cement with MSW is 7%, which give 1821psi, 2304psi and 3036psi of compressive strength on 7th, 14th and 28th day, respectively (Mustafa and Serdal 2007 and Mehmet *et al*., 2012).

The Fig. 2 shows the results of compressive strength of concrete where, the MSW was used as an additive in contrast to the initial step of this study. For the previous work done, and from the initial investigation of the current study, two compositions, i.e., 10% and 20% was used in this phase of the study. The sample without marble powder was taken as standard or reference. Then the effect of MSW was evaluated as an additive and in the next two mixes 10% and 20% MSW by weight of cement was added. An increase in the compressive strength of concrete was observed. As indicated in the Fig. 2, an increase is about 7% and 4% by addition of 10% and 20% MSW at 28-Days of curing. The overall increase in the compressive strength of concrete might be due to the higher percentage of calcium contents in the MSW as compared to that with the cement composition (Prassianakis, 2004). The Figure 3 shows the results Slump Test conducted on the concrete batches designed with different cement: MSW ratios. It indicates that samples with 0% 5% 6% 7% 8% 9% 10% 20% 30% and 40% replacement of cement with MSW have a slump value between ranging from 2-1.5inches, whereas that with 50% 60% 70% and 80% of MSW have a 1-1.5 inches. And the sample with 90% and 100% MSW have “0” slump, that indicates that the replacement of cement with MSW would decrease the workability of concrete (Belaidi *et al*., 2012). The slump value has reduced due to replacement of cement with MSW as well as due to addition of marble powder. The content of lime is much more almost 98% in the local material as compared to previous researchers (Gazi *et al*. 2012, Gulsen *et al*., 2014). The Tensile Splitting Test (TST) of concrete was also conducted. Fig. 4 and 5 shows the results of TST, for the samples with partial replacement of cement with MSW and the samples with MSW as an additive, respectively.

The sample with 0% MSW shows a tensile strength of more than 35tons, equivalent to 715psi. And the samples with 5% 6% 7% and 8% give a tensile strength of 25-35tons. A more drop in the value of tensile strength was also noticed with the increase in the percentage of MSW. As the samples with 9% 10% and 20% replacement of cement with MSW showed strength of 20-25 tones. Furthermore, the samples with 90% and 100% MSW was observed to have “0” tensile strength. This indicates that the tensile strength of the concrete is subjected to the availability of cement contents in it. In case of the use of MSW as an additive in concrete, the TST was carried out at 28-Days, the results of which are shown in the Fig. 5. It indicates an increase of 6-8% in splitting tensile strength of concrete after the addition of 10-20% MSW to it. The compressive strength of the concrete, using more than 7% of MSW (by weight), is less than the standard concrete, it illustrates that the compressive strength of concrete decreases with the increase of MSW. It was also noticed that the compressive strength of concrete increases significantly by addition of MSW. The increase in strength may be due to the reaction of lime CaO with silica in the presence of water to form calcium silicate hydrate. The same fact has been pointed out by different researchers previously (Ilker *et al*. 2009, Akkurt *et al*., 2012). So the concrete having MSW as additive is satisfactory from strength parameters. The statistics shown indicate that concrete blocks containing MSW more than 7% cannot be used in heavy load bearing structures. And at the same time,

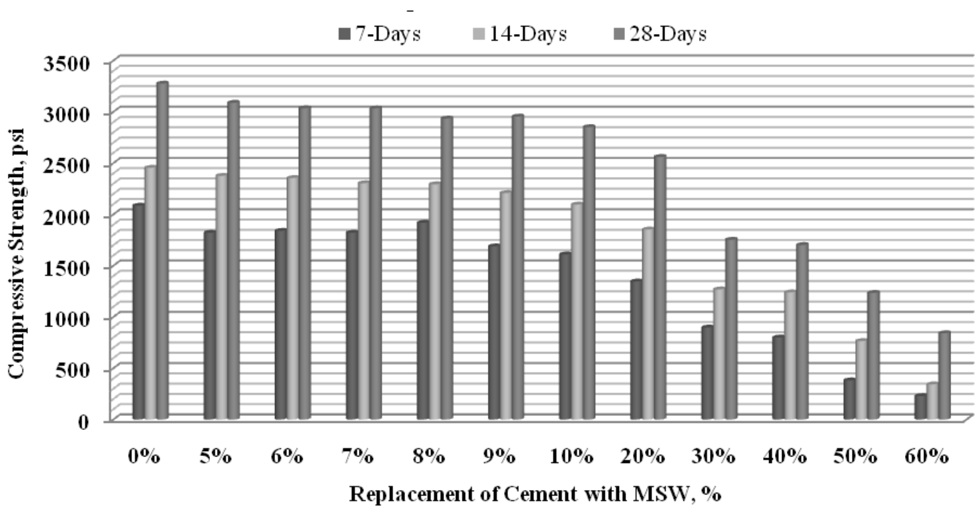

Fig. 1. Compressive strength of concrete with partial replacement of cement with MSW

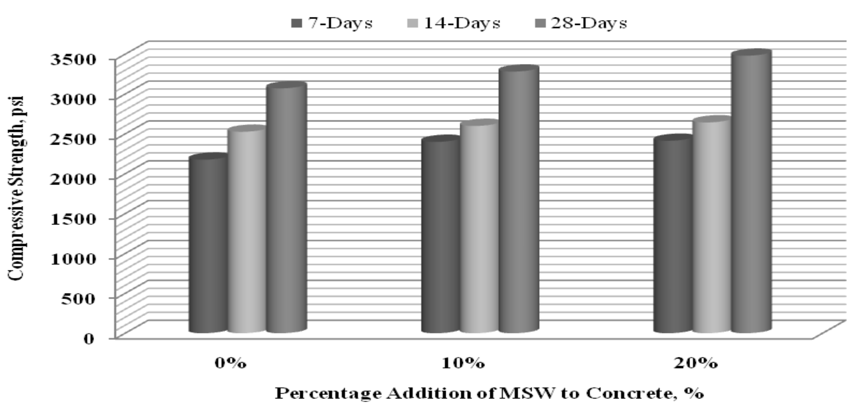

Fig. 2. Compressive strength of concrete with addition of MSW

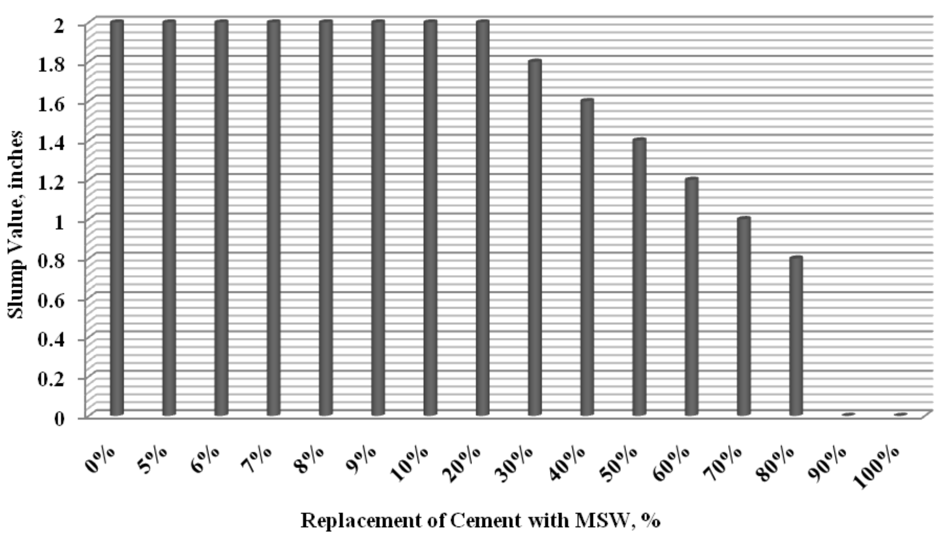

Fig. 3. Results of slump test of concrete with partial replacement of cement with MSW

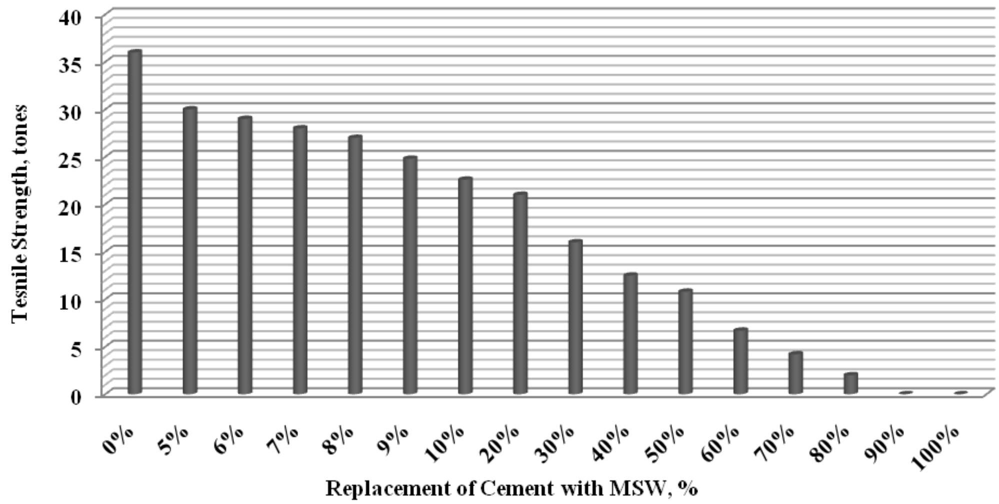

Fig. 4. Tensile Strength of concrete with partial replacement of cement with MSW

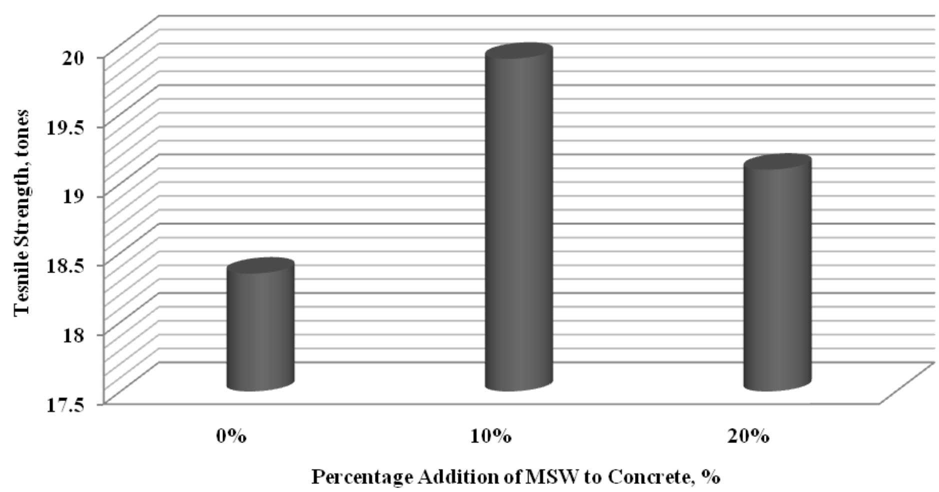

Fig. 5. Tensile Strength of concrete with addition of MSW

the MSW concrete blocks can put into beneficial use for many reasons, like, non-load bearing or partition walls, in framed structures where load is distributed on tie beams or earth beams, or in pavement for walks ways, footpaths and such similar structures etc (Hebhoub *et al*., 2011, Huseyin and Cahit 2010).

The results show that the use of MSW in concrete making a cost-effective mode of safe disposal of solid wastes, which is posing a sever threat to the environment. As the cost analysis of the cubic meter of concrete indicates that the cost of concrete decrease with the addition or replacement of MSW in it. For instance, when the cost of one cubic meter of concrete was analyzed, it concluded that with 7% and 20% of cement replacement with MSW decrease its cost by 10% and 24%, respectively.

CONCLUSION

The disposal of locally abundant MSW is a critical environmental issue that needs to be addressed. However, it has higher calcium content, i.e., more than 97% on account of which it could be easily and cheaply used in the construction industry. The concrete with 7% partial replacement of cement with MSW can provide a compressive strength and tensile splitting strength of more than 3000psi and 28tones, respectively. Though the workability of concrete will slightly decrease, but still it can be used safely in the concrete of non-load bearing structures. Furthermore, studies are required to investigate the effects of other various MSW compositions and various concrete mix design ratios other than the one used. Moreover, study can be done on MSW replacement with other ingredients of the concrete, like fine and coarse aggregate etc to check its engineering qualities for concrete usage

REFERENCES

Akkurt, R., Altindag, K., Gunoglu, H. and Sarýkaya, K. (2012). Photon attenuation coefficients of concrete including marble aggregates. Annals of Nuclear Energy, **43**, 56-60.

Ali, A., Aliabdo, A. E. M., Esraa, M. and Auda, K. (2014). Re-use of waste marble dust in the production of cement and concrete. Construction and Building Materials, **50**, 28-41.

Ali, E. (2011). Effects of the usage of diatomite and waste marble powder as partial replacement of cement on the mechanical properties of concrete. Construction and Building Materials, **25 (2)**, 806-812.

Bacarji, E., Toledo, F. R. D., Koenders, E. A. B., Figueiredo, E. P. and Lopes, J. L. M. (2013). Sustainability perspective of marble and granite residues as concrete fillers. Construction and Building Materials, **45**, 1-10.

Belaidi, L., Azzouz, E., Kadri, S. and Kenai, M. (2012). Effect of natural pozzolana and marble powder on the properties of self-compacting concrete. Construction and Building Materials, **31**, 251-257.

Bilgin, N., Yeprem, H. A., Arslan, S., Bilgin, A., Gunay, E. and Marsoglu, M. (2012). Use of waste marble powder in brick industry. Construction and Building Materials, **29**, 449-457.

Gameiro, F., Brito, J. and Correia, S. D. (2014). Durability performance of structural concrete containing fine aggregates from waste generated by marble quarrying industry. Engineering Structures, **59**, 654-662.

Gazi, G., Skevis, M. A. and Founti, I. (2012). Energy efficiency and environmental assessment of a typical marble quarry and processing plant. Journal of Cleaner Production, **32**, 10-21.

Gonzalo, M. B., Carmina, M. C. and Osman, G. (2013). Polyester polymer concrete: Effect of the marble particle sizes and high gamma radiation doses. Construction and Building Materials, **41**, 204-208.

Gulsen, T., Ali, I. A., Taskin, O. and Ekrem, K. (2014). Using marble wastes as a soil amendment for acidic soil neutralization. Journal of Environmental Management, **133**, 374-377.

Hanifi, B., Tahir, S., Orhan, A. and Hasan, K. (2008). Durability of concrete made with granite and marble as recycle aggregates. Journal of Materials Processing Technology, **208 (1–3)**, 299-308.

Hebhoub, H., Aoun, H., Belachia, M., Houari, H. and Ghorbel, E. (2011). Use of waste marble aggregates in concrete. Construction and Building Materials, **25 (3)**, 1167-1171.

Huseyin, A. and Cahit, G. (2007). Use of aggregates produced from marble quarry waste in asphalt pavements. Building and Environment, **42 (5)**, 1921-1930.

Huseyin, A., Metin, G., Mustafa, D. and Ilker, T. (2010). Utilization of waste marble dust as an additive in cement production. Materials and Design, **31 (8)**, 4039-4042.

Ilker, B. T., Turhan, B. and Tayfun, U. (2009). Effect of waste marble dust content as filler on properties of self-compacting concrete. Construction and Building Materials, **23 (5)**, 1947-1953.

Khalil, A., Shaikh, S. N., Nudrat, Z. R. and Farzana, H. (2013). The effect of silica on the properties of marble sludge filled hybrid natural rubber composites. Journal of King Saud University - Science, **25 (4)**, 331-339.

Kursat, E. A. and Ragip, I. (2009). A preliminary concrete mix design for SCC with marble powders. Construction and Building Materials, **23 (3)**, 1201-1210.

Mehmet, G., Erhan, G., Mustafa, E., Kocabag, V. B. and Kasým, M. (2012) Fresh and hardened characteristics of self compacting concretes made with combined use of marble powder, limestone filler, and fly ash. Construction and Building Materials, **37**, 160-170.

Mustafa, K. and Serdal, T. (2007). Evaluation of marble waste dust in the mixture of asphaltic concrete. Construction and Building Materials, **21 (3)**, 616-620.

Omar, M., Ghada, D., Elhameed, A., Mohamed, A., Sherif, H. and Mohamadien, A. (2012). Influence of limestone waste as partial replacement material for sand and marble powder in concrete properties. HBRC Journal, **8 (3),** 193-203.

Osman, G., Cengiz, O., Fuat, K., Ertugrul, E., Gonzalo, M. B. and Witold, B. (2012). Properties of concrete paving blocks made with waste marble. Journal of Cleaner Production, **21 (1)**, 62-70.

Pawan, K., Anurag, M., Ramesh, C. G., Laszlo, C., Vimal, G. and Amarnath, A. (2013). Mechanical and durability studies on concrete containing wollastonite–fly ash combination. Construction and Building Materials, **40**, Pages 1142-1150.

Prassianakis, N. I. (2004). Ultrasonic testing of non-metallic materials: concrete and marble. Theoretical and Applied Fracture Mechanics, **42 (2)**, 191-198.

Valeria, C., Giacomo, M. and Tarun, R. N. (2010). Characterization of marble powder for its use in mortar and concrete. Construction and Building Materials, **24 (1),** 113-117