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PERFORMANCE EVALUATION OF FEASIBILITY OF PARTIAL REPLACEMENT OF INDUSTRIAL WASTE IN FLEXIBLE PAVEMENT LAYER

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ABSTRACT

The object of the existing practice is to prepare a unique type of WMM (Wet Mix Macadam) Base course by using a modern Industrial effluent materials such as Steel slag (SS), Fly ash (FA), Phosphogypsum(PS) and Demolished Concrete waste(DCW) replaced in traditional WMM mix. The optimal mix proportion of Modified WMM denotes (5% of steel slag, 5 % of fly ash (FA), 5 % of demolished concrete waste with Phosphogypsum (PS) 3.5%). This Modified WMM Mix was replaced in conventional WMM Mix for Strength improvement. This Conventional WMM Mix fraction contains (43% of 40 mm crushed aggregate, 8% of 20 mm crushed aggregate,21% of 10 mm aggregate and 28% stone dust). The strength rise was determined by carrying the CBR test, dry density of mix and plate load test, from these tests, the obtained results compared with traditional WMM Mix Strength. The concerned CBR value of modified WMM is 17.01 % & MDD is 2.710 gm/cc. From Plate load test, it gives the least settlement & has great dry density compared to the conventional mix. This modified WMM Mix has best water stability against Conventional WMM Mix. Employing this altered WMM mix in the flexible pavement, increase in strength and high water stability & more durable. Using this type of roadways, decrease the industrial waste growth and minimize the pollution of the environment

. **Keywords:** Steel slag; Fly ash; Phosphogypsum; Demolished concrete waste.

1. INTRODUCTION

Nowadays different waste delivered from several Industries is an improbable issue. These materials will lead to pollution of the environment; this industrial waste contains a vast number of non-biodegradable substances. As of late, utilization of this industrial waste has been considered in pavement construction with incredible enthusiasm for creating communities. The usage depended on specialized, financial, and living criteria. The absence of conventional pavement materials and the protection of nature make it essential to examine the credible utilization of these materials. Usually, soil, stone fragments, sand, bitumen, cement concrete and so forth utilized for Pavement Construction. Regular elements being modest, its amount is declining continuously. Likewise, the cost of conventional materials is increasing rapidly. Worried about this, the researchers are searching for best replaceable substances for pavement development. There is a chance that these materials can be reasonably used in thruway development, the pollution, and disposal issues might be somewhat diminished. Recognizing the requirement for utilization of these wastes in India, in which higher financial returns might be credible. The credible utilization of these materials ought to be created for the development of low-volume pavements in several parts of our nation.

1.1. Back ground: In India about 40% of land region is covered by clay soil and about 30% of clay soils are swelling in nature. Because of this the asphalts on clay soil pavements don't serve for long and offer helpless riding surface. Thus, endeavors are being made to improve the asphalt layer strength by settling it with modern waste

1.2. Objectives:

- The major objective of this study is to use the properties of industrial waste in base course of different proportions to control the fatigue behavior of binder course.
- To create modified form of wet mix macadam which can hold the maximum stresses compare to normal wet mix macadam
- To show the solution for industrial waste by using them in construction area

2. MATERIALS

2.1 Steel Slag (SS)

Steel slag is produced from steel making process is created amid the partition of the liquid steel from impurities in steel-production heaters. The slag happens as liquid fluids liquefy and is an unpredictable arrangement of silicates and oxides that set after cooling.

2.2 Fly Ash (FA)

Fly ash is the fine particulate waste material created by the pummeled coal-based power station, is a natural toxin, it can possibly be an asset material. This ash utilized as a constituent of the cement, concrete and other bond based applications in India. According to IS 3812: 2003, the non-specific name of the waste item because of consumption of coal or lignite in the evaporator of a warm power plant is pounded fuel fiery remains. Pummeled fuel fiery remains can be fly cinder, base powder, lake slag or hill slag. Fly ash is the pounded fuel powder removed from the fuel gases by any appropriate procedure like violent wind partition or electrostatic precipitation. Pounded fly fiery remains gathered from the base of boilers by any reasonable procedure is named as Bottom Ash. The wording Pond Ash is utilized when fly powder or base fiery debris or both blended to any extent is passed on as water slurry is saved in a lake or tidal pond. At the point when fly- ash or base cinder or blend of these to any extent is passed on or conveyed in a dry frame and kept dry, it is known as Mound Ash. There will be an increase in strength during the hydration process which reacts with the additional production of hydrates of calcium silicate due to reactivity of silica with fly ash [1]

2.3 Demolished Concrete Waste (DCW)

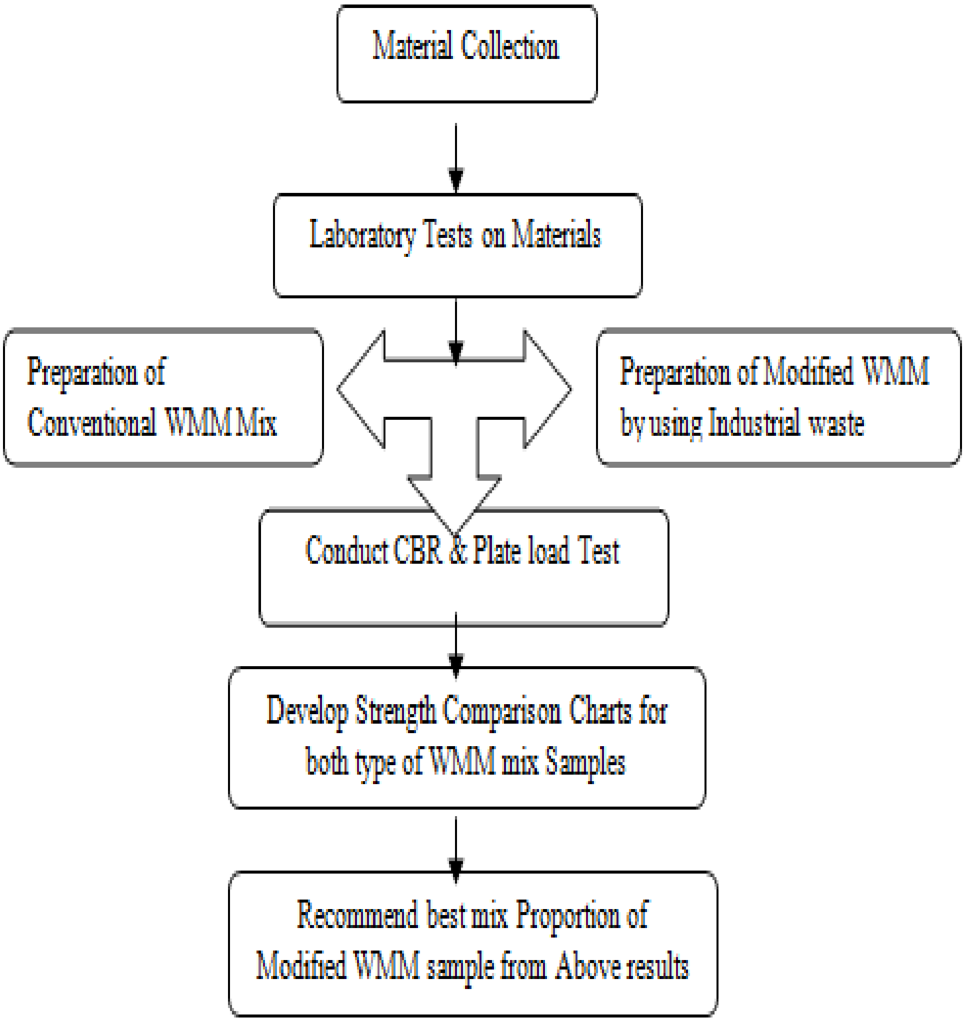
Nowadays in everywhere, we are using Concrete Structures, These Concrete structures have the more strength compared to other types of structures. After the Completion of life of the Concrete structure, it requires demolition. This demolition produces a lot of concrete and other building material wastes; this waste has the good engineering properties. In India 530 million tones of demolished waste produced annually. This waste creates a lot of nuisance and inconvenience to the environment. Many researchers are advised that demolition waste is utilized in pavement construction and building constructions. By using this DCW in various type of constructions there may be a possibility of cost reduction. The replacement of natural aggregates by using recycled aggregates from construction and demolition waste is showing potential function in construction as substitute to natural fresh aggregates

This waste is crushed into desired particles by using stone crushers, after that classify the crushed particles based on the sieve size. The IS strainers used were – 80mm, 40mm, 20mm, 10mm, 4.75mm, 2.36mm, 1.18mm, 600µ, 300µ and 150µ. The parts passing 20mm and hung on 4.75mm IS sifter were used as coarse aggregate for substitution. The parts passing 4.75mm and hung on 600µ IS strainer were used as fine aggregate for substitution. The divisions passing 600µ IS strainer were considered as powder and used for substitution of bond in reused strong making.

2.4 Phosphogypsum (PS)

Phosphogypsum is calcium sulfate hydrate which is induced by the fertilizer making process. For fertilizer making, phosphoric acid required, this phosphoric acid collected from phosphate ore (apatite) which reacts with sulfuric acid. At the time of phosphoric acid production, phosphogypsum also produced this phosphogypsum is a radioactive material, which causes the pollution of the environment when improper disposal obtained. Phosphogypsum is an excellent binding material, and it also contains excellent engineering properties. In India, 12 million tons of phosphogypsum waste is inducing annually. Phosphogypsum is a toxic material not exposed to the atmosphere; stacking phosphogypsum is dangerous to the ecosystem. To prevent pollution of the environment produced by the phosphogypsum is to recycle or it can use for various purposes. Researchers said that for best results phosphogypsum is used in pavement construction of below ground level.

3. METHODOLOGY



Initially collect all material together; the materials are Steel Slag, Fly ash, Phosphogypsum, Demolished Concrete Waste and Various sizes of Coarse Aggregates & Murrum. These materials no need to treat except demolished solid waste and Coarse aggregate. Crush the demolished Concrete debris into smaller particles. Then conduct Sieve analysis, differentiate the sieve size of 40 mm passed, and 20 mm Size retained. This Size of demolished waste used as an aggregate in modified WMM. Conduct sieve analysis for Coarse conventional aggregates also. Arrange them into 40mm, 20mm, and 10mm sizes for traditional WMM.

After the collection of materials, conduct Specific gravity test on each substance. Then perform the Aggregate Impact value & Flakiness elongation Index, LL &PL of elements. Compaction Test, CBR and Plate load test for WMM mixes.

4. CONVENTIONAL WMM MIX DESIGN

Based on the individual materials test results Mix design will be prepare by using Blending curve of aggregates. The summary sheet of the WMM mix is given below.

Table 1 Summary sheet Conventional WMM Mix

SUMMARY SHEET FOR DESIGN MIX OF WMM					
Source of Material	Godavarikhani				Limits as per MORTH
Type of Material	40mm Agg	20mm Agg	10mm Agg	Stone Dust	
Mix proportion (%)	43%	8%	21%	28%	-
Specific gravity	2.620	2.619	2.618	2.608	-
Water Absorption (%)	1.11	1.20	1.35	1.63	1.20
Aggregate Impact Value (%) Avg .of 40 and 20&10mm	20.21				<30%
Liquid Limit(%)	22.00				-
Plasticity Index (%)	NP				<6%
FI & EI Index(%)(40,20&10mm)	28.08				<30%
M DD(gm/cc)	2.287				-
O M C (%)	5.50				-

The obtained Mix Proportion of Conventional WMM Mix is (43% of 40mm aggregate and 8% of 20 mm& 21% of 10 mm & 28% of Stone Dust).

5. MODIFIED WMM MIX SAMPLING

Mix A Steel slag 5%, Fly ash 5%, Demolished Concrete Waste 5% & Phosphogypsum 1%

Mix B Steel slag 5%, Fly ash 5%, Demolished Concrete Waste 5% & phosphogypsum 2%

Mix C Steel slag 5%, Fly ash 5%, Demolished Concrete Waste 5% & phosphogypsum 3%

Mix D Steel slag 5%, Fly ash 5%, Demolished Concrete Waste 5% & phosphogypsum 3.5%

Mix E Steel slag 5%, Fly ash 5%, Demolished Concrete Waste 5% & phosphogypsum 4%

5.1 Cbr Results

Tab 2.shows the

California Bearing Ratio (CBR) test is a penetration test. The test used for determining the sub-grade strength. This analysis conducted by measuring load required to penetrate a soil sample at a standard rate with a piston under standard conditions. The measured load divided by the load required to achieve an equal deformation on a standard crushed rock material. Fig 1.shows the CBR results for different mix.

Table 2 CBR Results for WMM mixes

Type of Mix	C.B.R value at 2.5 mm Penetration (%)	C.B.R value at 5.0 mm Penetration (%)
WMM	15.2	12.88
MIX A	10.12	9.81
MIX B	12.88	9.81
MIX C	16.55	14.1
MIX D	17.01	14.71
MIX E	11.04	9.2

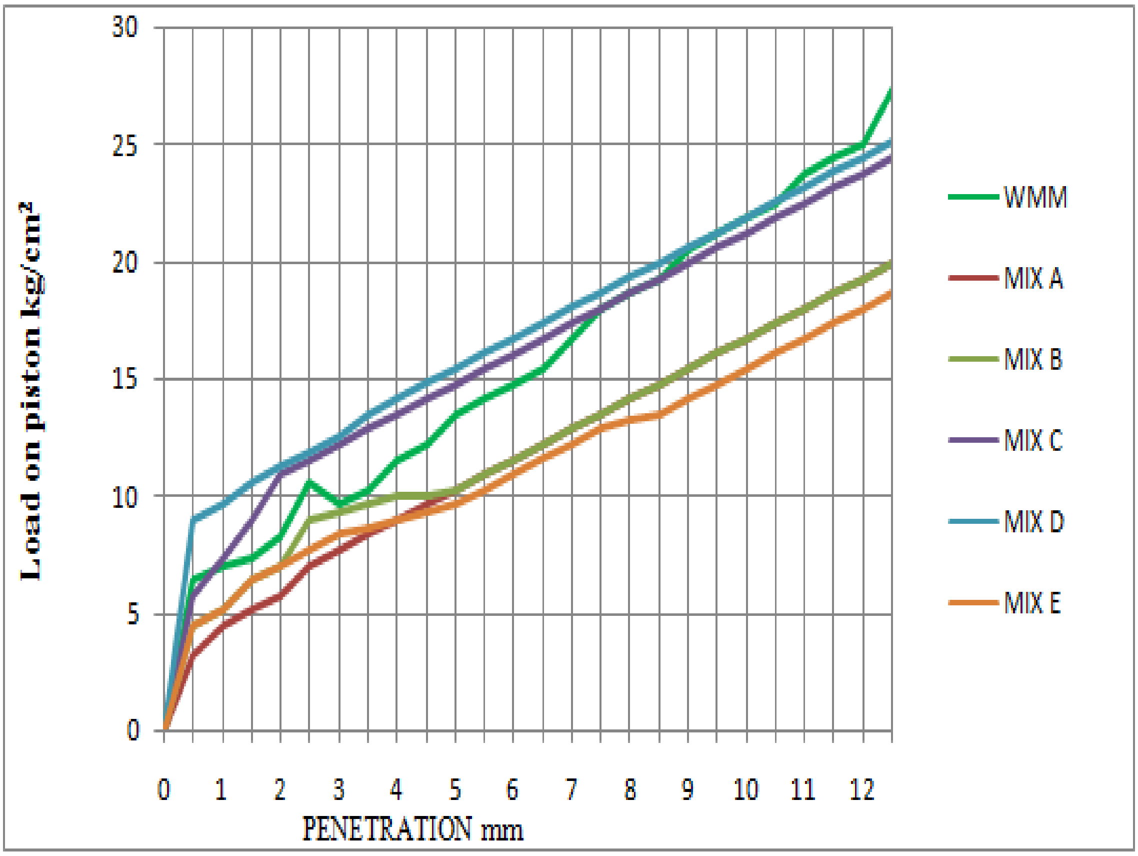


Fig.1 CBR Results Graph for Different WMM Mixes

From CBR test results WMM mix having the value of 15.2% and at mix D (SS 5%; FA 5%; DWA 5%; PG 3.5%) has highest CBR value of 17.1%. From this results we observe phosphogypsum plays major role, increase in the strength of the mix. At 3.5% of phosphogypsum gives more strength to the pavement.

5.2 Plate Load Test

Table 3 shows the Plate load Test for Different WMM Mixes and fig.2. shows the plate load test load settlement

Table 3 Plate load Test for Different WMM Mixes

load pressure (kn/m2)	wmm mix settlement (mm)	mix a settlement (mm)	mix b settlement (mm)	mix c settlement (mm)	mix d settlement (mm)	MIX E Settlement (mm)
0	0	0	0	0	0	0
50	0.63	0.553	0.32	0.32	0.293	0.443
100	0.786	0.703	0.636	0.45	0.43	0.563
200	1.116	1.003	0.903	0.703	0.703	0.803
300	1.563	1.58	1.36	1.133	1.176	1.183
400	1.736	1.903	1.87	1.386	1.35	1.516
500	1.95	2.517	2.183	1.773	1.673	1.773
600	2.24	3.1	3.033	2.333	2.016	2.05
700	4.163	4.96	4.4	3.473	2.86	3.2
800	5.003	5.803	5.37	4.203	3.34	4.46
900	8.37	8.7	8.54	7.93	6.13	8.87
1000	9.47	9.74	9.66	8.94	7.47	9.73

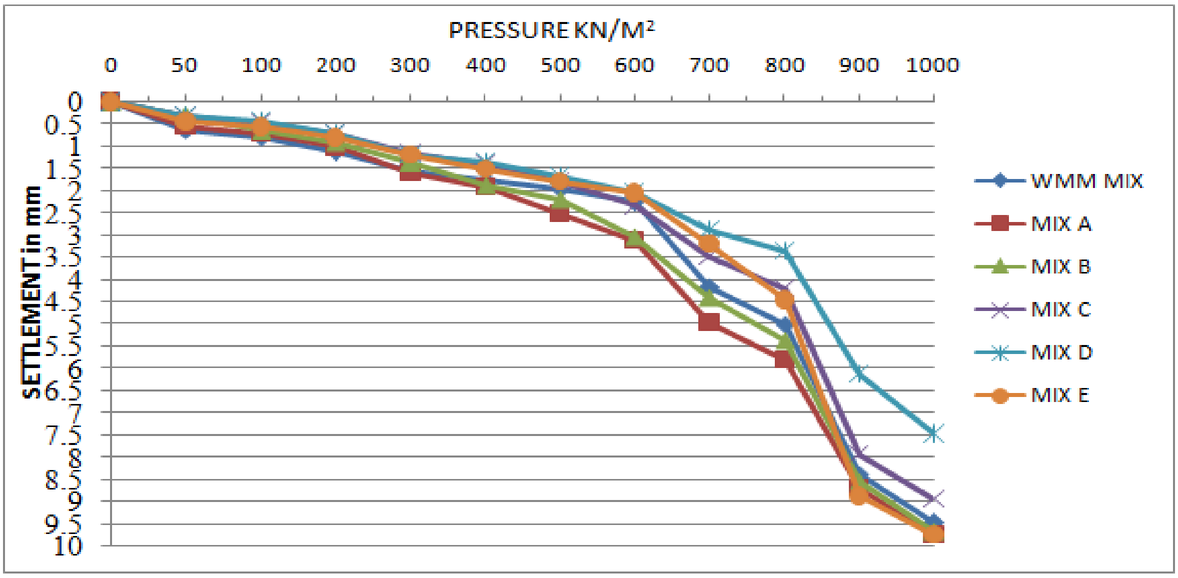


FIG.2 PLATE LOAD TEST RESULTS GRAPH FOR DIFFERENT WMM MIXES

By observing plate load test WMM mix fails at 600KN/M^2 load, and Mix D fails at 700 KN/M^2 load. So that Mix D having the greater strength. But settlement is little high of Mix D compared to the WMM mix, by adding phosphogypsum content settlement is increasing onwards. By considering CBR and Plate load test results Mix D (Steel slag 5%, Fly ash 5%, Demolished Concrete Waste 5% & phosphogypsum 3.5%) has the more strength.

6. DISCUSSIONS

From above results, Modified WMM mix has the more strength and less settlement & having high dry density compared to traditional WMM mix, so that we can use this mix as a base course in flexible pavement, and achieve less thickness of pavement. Using Mix D we can achieve greater strength. By using this mix in pavements, reduce the cost of material and reduce the thickness of the pavement, In this mix phosphogypsum plays major role for strength improvement.

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6.1. LIMITATIONS

The phosphogypsum 3.5% gives the more strength. For strength development steel slag and phosphogypsum plays major role and it also improves the life span of the road. Increase in usage of Phosphogypsum will decrease the strength of the structure

7. CONCLUSION

The available research points out that there is adequate scope for utilization of waste materials for road construction. However, one needs to proceed carefully, because of possible environmental, health and safety concerns associated with the usage of some of the waste materials. Thus, additional research is needed before any definite waste material finally approved as an alternative road construction material. It hoped that the availability of proper technology, relevant enactment and awareness among all stakeholders would widen the possibilities of using some of the waste materials for sustainable road construction. It seems that some of the industrial waste may achieve a proper usage in highway construction. However, environmental consequences of reuse of such body need thoroughly investigated. An assessment in light of specialized, ecological, and monetary components showed that recovered clearing body, coal fly fiery debris (FA), steel slag, and decimated squander with phosphogypsum can possibly substitute ordinary body for different applications in interstate development and ought to be anticipated for future improvement. Technical economic and an environmental problem associated with various applications of waste, identified under each waste form and briefly discussed must address before extensive use of these waste outputs in highway construction. There is an increase in the CBR value when Phosphogypsum (PS) and steel slag, demolished concrete waste (DCW), and fly ash (FA) mixed with the samples.

7.1. FUTURE WORK

By finding the more industrial waste which is suitable for construction of pavements has to be done with appropriate combinations .compare the results with laboratory results with software analysis, this will give the perfect mix proportion strength for pavements.

Conflicts of Interest

The authors declare no conflict of interest

Author Contributions

Many thanks to my guide for making me to think in different way of approach towards the research

REFERENCES

[1] Karthik M , Shashank V B , Ajey Kumar V G, An Experimental Study of Pavement Quality Concrete for Rural Roads in India Using Plastic and Industrial Wastes. International Journal of Emerging Trends in Engineering Research, Volume 8. No. 8, August 2020.

[2] B. Ramakrishna, B. Harshini , G.N.K. Iswarya Lakshmi , K. Sangireddy , K. Pavan Krishna Prasad, Influence Of Fly Ash On The Properties Of Recycled Coarse Aggregate Concrete. International Journal of Emerging Trends in Engineering Research, Volume 8. No. 5, May 2020.

[3] Sharon Ranjitha Paul and C R Ramakrishnaiah. “Solidification and stabilization of expired chemicals”. International Journal of Advanced Technology and Engineering Exploration, Vol 5(44),2018.

[4] MustaphaAmrani,YassineTaha,AzzouzKchikach,MostafaBenzaazoua,RachidHakkou.”Phosphogypsum recycling: new horizons for a more sustainable road material application”. Journal, Volume, July 2020, 101267.

[5] M.I.Romero-Hermida,A.M.Borrero-López,F.J.Alejandre[c]V.Flores-Alés,A.Santos,J.M.Franco,L.Esquivias.”Phosphogypsum waste lime as a promising substitute of commercial limes: A rheological approach”. Composites, Volume, January 2019, Pages 205-216.

[6] DayoungOh,TakafumiNoguchi,RyomaKitagaki,HyeonggilChoi.”Proposal of demolished concrete recycling system based on performance evaluation of inorganic building materials manufactured from waste concrete powder”. Renewable and Sustainable Energy Reviews, 2020.1364-032

[7] Ahmed Arqam Ruknuddin, Nischitha C S, Chethan L, Manoj P. "Stabilization of Subgrade Soil using Reclaimed Asphalt Pavement (RAP)". International Journal of Engineering and Advanced Technology (IJEAT) ISSN: 2249-8958, Volume-8 Issue-5, June 2019.

[8] G. V. Praveen, S. Goverdhan Reddy. "Liquifaction – a Geotechnical Engineering Challenge In Pavement Construction" International Journal of Innovative Technology and Exploring Engineering (IJITEE) ISSN: 2278-3075, Volume-8 Issue-2S December, 2018.

[9] Faizan Zargar, Punit Verma, Sandeep Singla. "Use of Reclaimed Asphalt Pavement and Bagasse Ash in Bituminous Flexible Pavement". International Journal of Innovative Technology and Exploring Engineering (IJITEE) ISSN: 2278-3075, Volume-9 Issue-2, December 2019.

[10] Huang B., (2009). " Laboratory evaluation of incorporating waste ceramic materials into Portland cement and asphaltic concrete." Construction and Building Materials, 23, 3451-3456.

[11] C.C. Onn, N.S. Mohd, C.W. Yuen, S.C. Loo, S. Koting, A.F. Abd Rashid, M.R. Karim, S. Yusoff, Greenhouse gas emissions associated with electric vehicle charging: The impact of electricity generation mix in a developing country, Transport. Res. Part D: Transp. Environ. 64 (2018) 15–22.

[12] F. Debieb, L. Courard, S. Kenai, R. Degeimbre, Mechanical and durability properties of concrete using contaminated recycled aggregates, Cem. Concr. Compos. 32 (6) (2010) 421–426.

[13] N. Serres, S. Braymand, F. Feugeas, Environmental evaluation of concrete made from recycled concrete aggregate implementing life cycle assessment, J. Build. Eng. 5 (2016) 24–33.

[14] DayoungOh,TakafumiNoguchi,RyomaKitagaki,HyeonggilChoi."Proposal of demolished concrete recycling system based on performance evaluation of inorganic building materials manufactured from waste concrete powder". Renewable and Sustainable Energy Reviews, 2020.1364-032.

[15] Wang, J., Vandevyvere, B., Vanhessche, S., Schroon, J., Boon, N., Belie, N.D., 2017. Microbial carbonate precipitation for the improvement of quality of recycled aggregates. J. Clean. Prod. 156, 355–366. https://doi.org/10.1016/j.jclepro.2017.04. 051.