IJCRT.ORG ISSN : 2320-2882
INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)
An International Open Access, Peer-reviewed, Refereed Journal

Experimental Investigation Of Plastic Grain Concrete Piles Using Temperature Sensor

[1]Kirit R. Prajapati, [2]Prof. Pratiti M. Bhatt, [3]Prof. Ghansyamkumar B. Rathod
[1]PG Scholar, [2]Assistant Professor, [3] Assistant Professor
[1,2]Department of Structural Engineering, [3]Department of Electronics and Communication Engineering
[1]Birla Vishvakarma Mahavidyalaya Engineering College, Vallabh Vidyanagar, India

Abstract: Nowadays, different types of replacement of sand by plastic grains in concrete is getting important in researches. In order to better understand the behavior of concrete piles during curing, exposure to different climatic conditions, and potential deterioration, this study investigates the compressive strength of plastic grain concrete pile by use of embedded temperature sensors.

After analysing characteristics of different plastic grain concrete (low density polyethylene, high density polyethylene and polypropylene), HDPE (high density polyethylene) is more sustainable with concrete mix. For this study compressive strength of plastic grain (high density polyethylene) pile is compared with M20 grade concrete pile. During the casting process, temperature sensors are first strategically inserted into concrete piles at top, centre and bottom as part of the research. The exothermic hydration response may be examined by the continuous temperature data recording that these sensors will provide during the curing process. From temperature data maturity and strength is calculated using Nurse- Saul (MNS) function.

***Index Terms* -** Concrete pile, Plastic grain, LDPE, HDPE, Polypropylene, Temperature sensor.

I. Introduction

Although conventional concrete piles are a mainstay in foundation building, their weight and environmental effect are major downsides. A viable substitute is plastic grain concrete (PGC). PGC is lighter and may have a smaller environmental impact because it is made using recycled plastic particles with replacement of some amount of natural aggregates & sand. Regarding the behavior of PGC piles under load and the impact of external conditions like temperature, there are, still, significant knowledge gaps.

PGC is an important advancement in the use of sustainable building techniques. It replaces some of the traditional aggregates like sand and gravel with recycled plastic particles mixed into the concrete mixture. This presents possible solutions for the management of plastic trash in addition to lowering the need for virgin materials.

The main parameters are workability, cost effectiveness and how do the mixing and pouring qualities of concrete change when plastic granules are present should be considered for investigation. All things considered, using plastic granules in concrete piles is a promising method for environmentally friendly building. They might become a more widely used and dependable foundation option as study continues.

Temperature has two main effects on concrete piles: it causes thermal strains and interferes with the curing process. Hydration is a chemical reaction that takes place during the curing of concrete. The heat released by this reaction can raise the temperature inside a thick concrete pile considerably. While they offer benefits, high heat can also hasten the curing process. The pile's center warms up more than its exterior. This may result in uneven curing and possible differences in the pile's strength.

Concrete expands and contracts in response to temperature changes. In particular, if temperature varies quickly, this may lead to strains within the pile. Cracking and a decrease in pile strength may result from these forces.

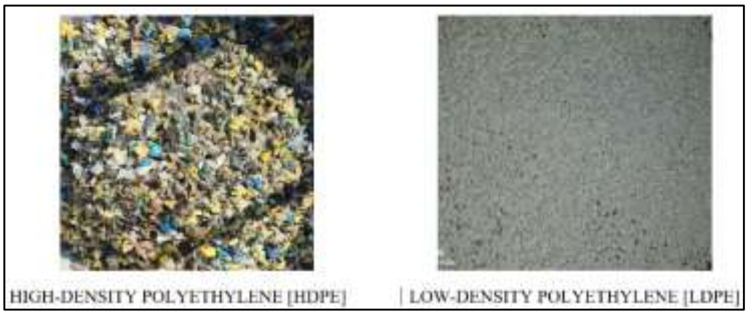

Figure 1 Plastic grain materials

II. LITERATURE REVIEW

Soutsos et al. [2018][1] used the modified Nurse-Saul (MNS) maturity function, offers improved strength estimates at higher curing temperatures. The early age development of compressive strength and the faster cement hydration at higher curing temperatures are suggested to be taken into consideration by applying a "acceleration" factor. A method known as the Nurse-Saul function is used to translate a temperature-time curing history into an equivalent age of curing at a point temperature. It looks to assess how steam curing processes affect the development of concrete strength by considering the combined effects of temperature and time. By adding two components to the Nurse-Saul maturity index, the recommended modified Nurse-Saul maturity function assesses or forecasts the strength development at temperatures other than the standard curing temperature of 20°C.

Geo et al. [2021][2] decided to investigate pertinent research that provided the soil's and concrete's heat properties. In addition, they looked into relevant literature, focusing on the strain and temperature coefficients of optical fiber sensors. The authors thoroughly studied earlier research to gain a comprehensive understanding of the thermal behavior of these materials as well as the performance characteristics of optical fiber sensors in sensing strain and temperature. The authors specifically emphasized the objectivity and neutrality of their writing. They were adamant that their research could not have been tainted by any overtly conflicting financial interests or personal relationships. This statement highlights the study's commitment to upholding the standards of academic honesty and scientific impartiality and assures readers that the research's conclusions are free from any unwarranted influence or prejudice. By doing this, Gao and associates show their dedication to transparent and impartial scientific study and advance our understanding of the thermal characteristics of soil, concrete, and optical fiber sensor coefficients.

Akinyele [2014][3] This study looks at replacing some of the fine aggregate in reinforced concrete beams with recycled polypropylene grains. It looks into the process of turning waste polyethylene materials into polypropylene grains and how they may be used in concrete. The sieve testing conducted by the authors revealed that 43.71 percent of the grains in the regenerated polypropylene waste passed through the 4.75 mm screen. This implies that the material can be categorized as suitably graded and suitable for usage as a fine aggregate replacement in concrete. In this experiment, concrete cubes and RC beams were made using varying percentages of recycled polypropylene (0, 4, 8, 12, and 16). A compressive strength test was conducted on the cubes, and a bending moment test was conducted on the beam's compressive strength of the 4-percent mixture was 16.28 N/mm2, while that of the control was 19.07 N/mm2. The bending moment test yielded the highest value for the control mix, 14.70 kN.m., while the mixes with 12 percent and 16 percent had the lowest values, 8.40 kN.m. each. Generally speaking, the polypropylene blends' deflections were higher than the control's. They discovered that, particularly when the replacement ratio is less than 4%, recycled polypropylene grains can replace some of the fine aggregate in concrete.

Gayatri [2020][4] investigated replacing fine aggregate in concrete with recovered plastic waste. Many academics have examined the effects of adding plastic to concrete, including how it affects split tensile strength and compressive strength. They suggested that the amount of plastic in concrete may affect its compressive strength, with a drop observed at higher amounts. However, the split tensile strength can be slightly raised by adding plastic. Studies have also been conducted on the effects of aggregate and plastic fibers on the mechanical properties of concrete. The results show that while compressive strength may not change, plastic aggregate can significantly affect the tensile strength of concrete. To improve the properties and durability of plastic-filled concrete, The study also highlights the use of mineral admixtures like fly ash and silica fume and the importance of grading plastic granules.

III. Material Validation

For material validation, different types of plastic grained are replaced by 10% of sand. For this study HDPE, LDPE and PP are used as plastic grains for concrete. All different types of plastic grained concrete are compared to M20 grade of concrete in bases of parameter like compressive strength and workability of concrete.

Table 1 Concrete mix design

MATERIAL	M20	HDPE	LDPE	PP
Cement	15KG	15KG	15KG	15KG
Sand	21KG	19KG	19KG	19KG
Aggregate	20MM-27KG 10MM-19KG	20MM-27KG 10MM-19KG	20MM-27KG 10MM-19KG	20MM-27KG 10MM-19KG
Water content	7LIT	7LIT	7LIT	7LIT
Replaced Material	-	2KG	2KG	2KG

Table 2 Workability results

TYPE OF TEST	M20	HDPE	LDPE	PP
TABLE FLOW TEST	30.75cm	30.8cm	31.75cm	31.75cm
COMPECTION FACTOR	0.894	0.880	0.910	0.862

Table 3 Compressive strength after 7 and 28 days

SAMPLE	M20	LDPE	HDPE	PP
COMPRESSIVE STRENGTH (7 days)	17.56 N/mm^2	20.48 N/mm^2	18.74 N/mm^2	15.25 N/mm^2
COMPRESSIVE STRENGTH (28 days)	24.23 N/mm^2	23.47 N/mm^2	33.83 N/mm^2	23.01 N/mm^2

After comparing results of plastic grained concrete with respect to M20 grade concrete, High Density Polypropylene (HDPE) grain concrete is more sustainable in terms of compressive strength.

IV. Experimental Setup of Pile and Data Calculation

Figure 2 shows main pile and one supporting pile are made up from M20 grade concrete and HDPE pile (replace with 10% of sand) are used for experimental investigation. Sensors are fastened to the steel reinforcing cage prior to the concrete being poured. These can be dispersed along the pile's length at different depths. These sensors are placed at top, middle and bottom of the pile. hydration process causes heat to be produced by the concrete as it ages. The temperature variations are recorded by the sensors throughout time.

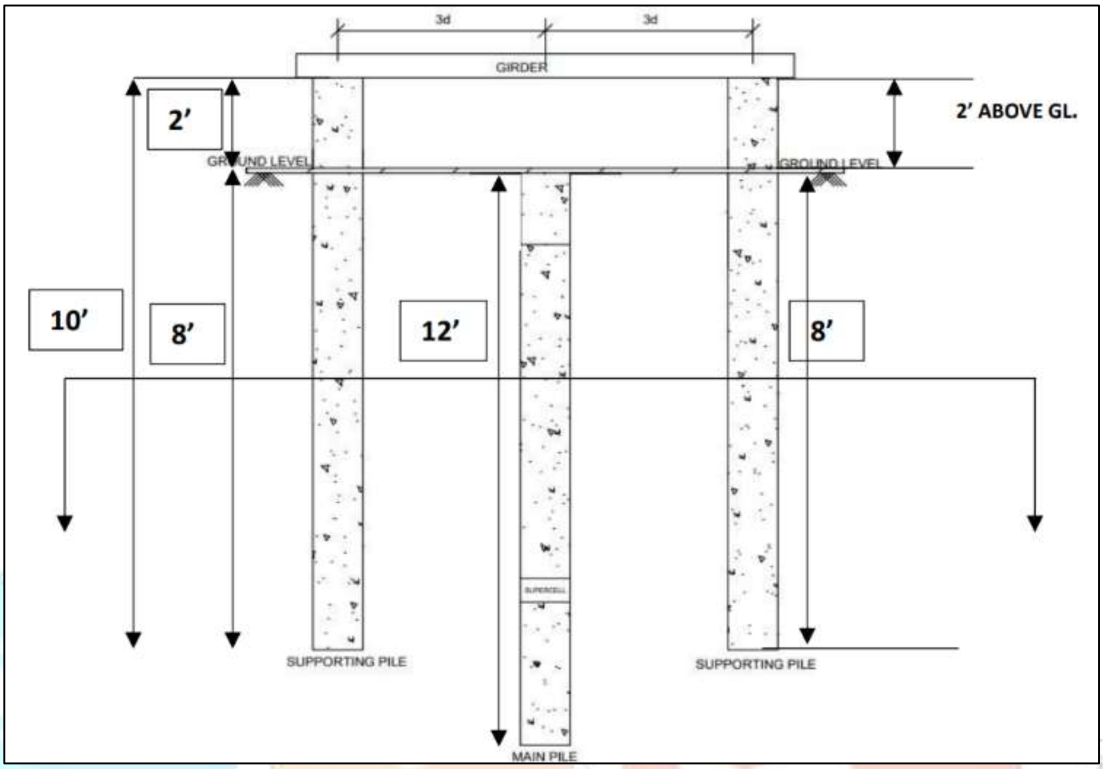

Figure 2 Basic data of piles

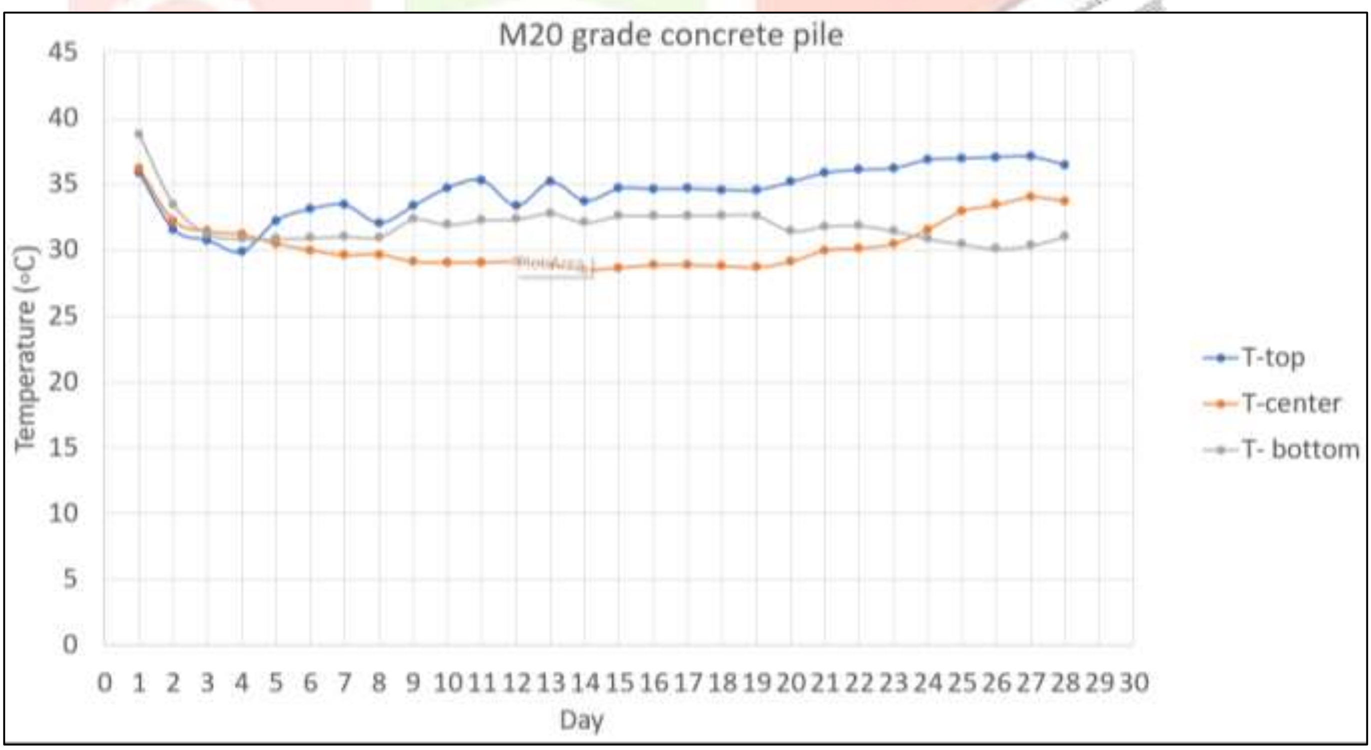

Figure 3 Temperature data of M20 grade concrete piles

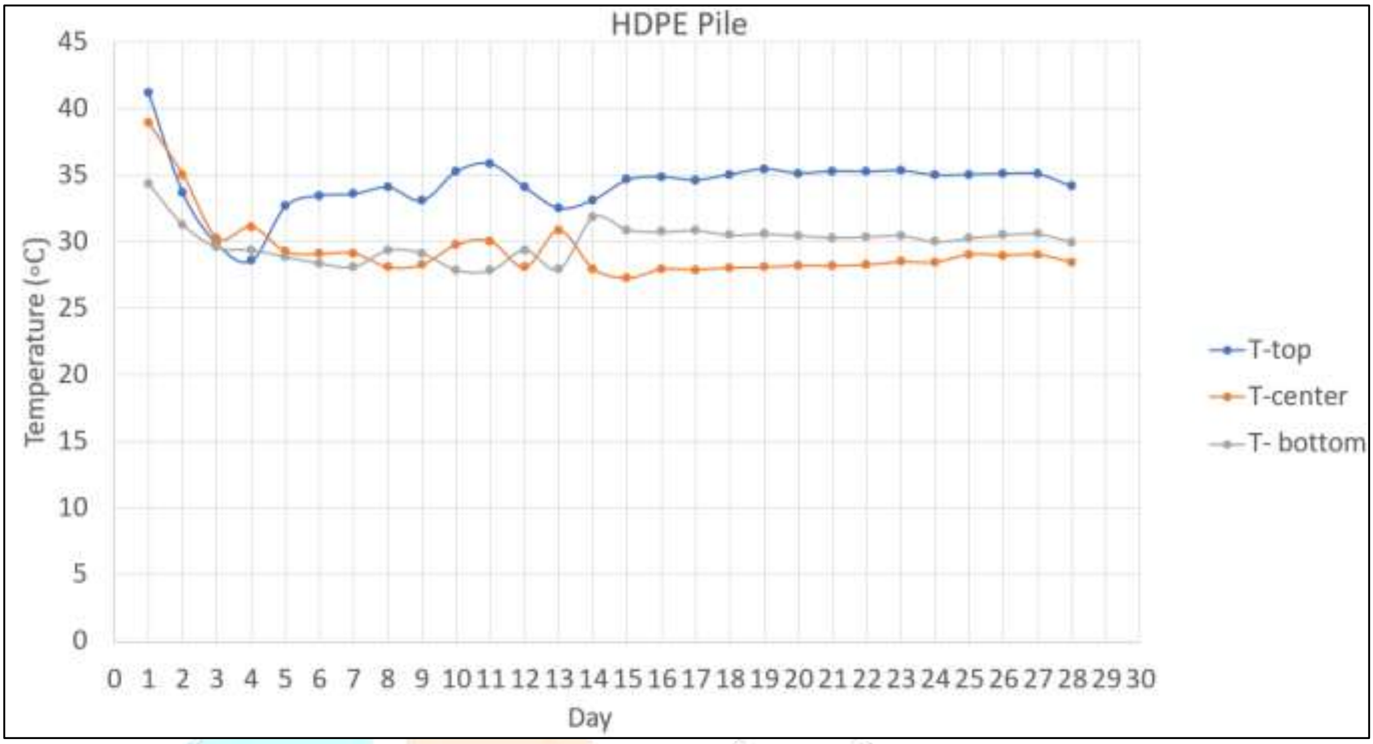

Figure 4 Temperature data of HDPE pile

From the temperature data shown in figure 3 and 4, maturity (M) is calculated using formula given below. Where, T_i is average temperature; T_0 is datum temperature assumed as 0 and Δt is temperature over time interval.

$$M = (T_i - T_0) * \Delta t$$

After calculating maturity, compressive strength of concrete is calculated using following expression in which A and B are constants.

$$S = A + B\log(\sum M/1000)$$

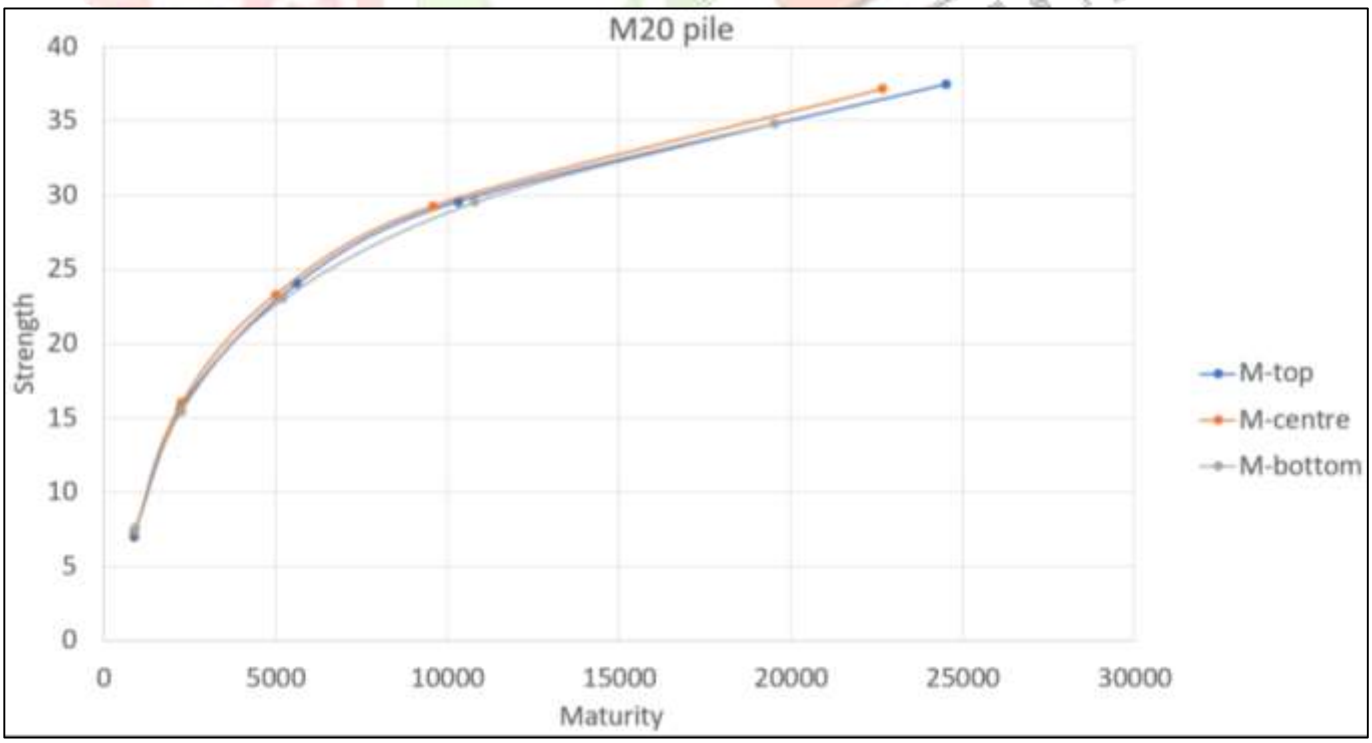

Figure 5 Strength vs Maturity (M20 grade concrete pile)

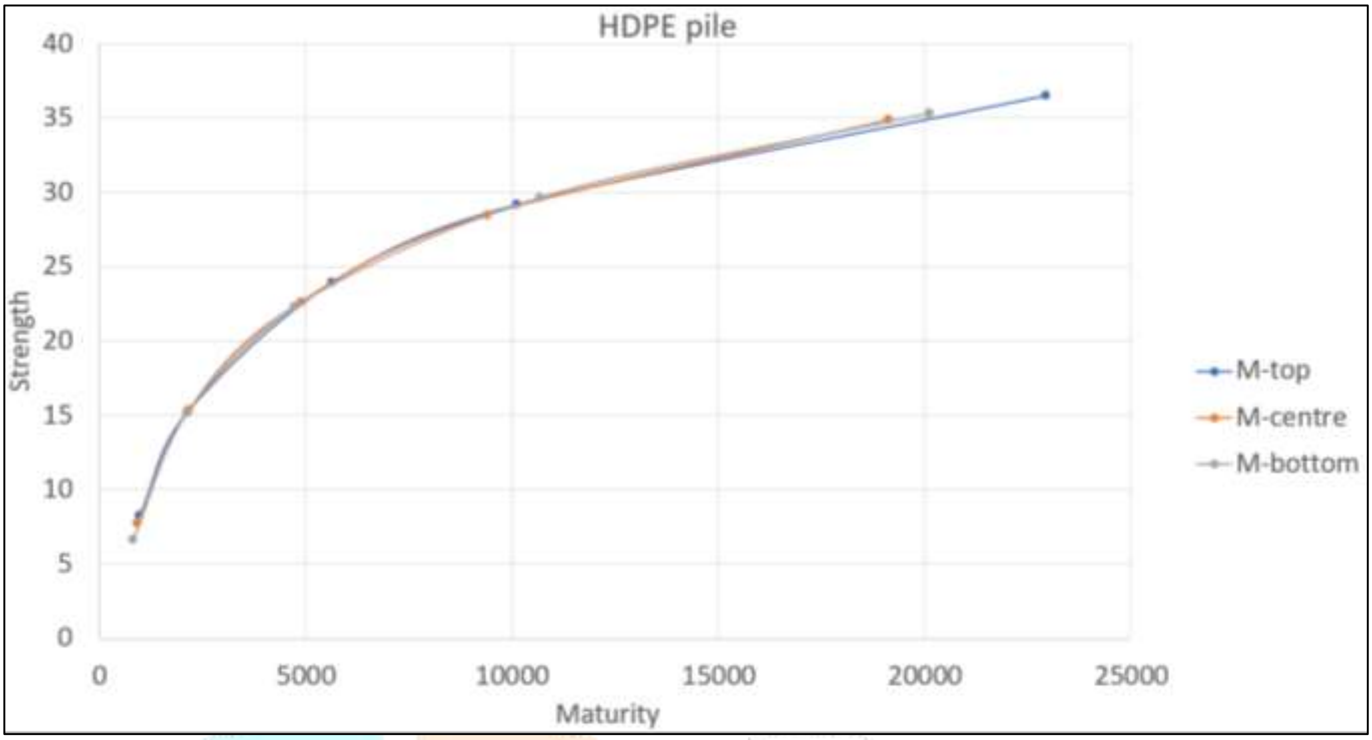

Figure 6 Strength vs Maturity (HDPE pile)

I. Conclusion

In this study, the development of compressive strength in concrete piles and HDPE (High-Density Polyethylene) at different temperatures has been investigated. The Nurse-Saul maturity function and temperature sensors were used to monitor the strength gain of both materials. For both HDPE and concrete piles, the Nurse-Saul function effectively correlated temperature data with strength development. Under the investigated conditions, the final compressive strength of HDPE (high density polyethylene) piles was very similar to that of M20 grade concrete piles. This study shows that adding plastic grain in concrete to replace sand doesn't compromise the compressive strength of M20 grade concrete.

References

[1] Soutsos M, Kanavaris F. The modified nurse-saul (MNS) maturity function for improved strength estimates at elevated curing temperatures. Case Studies in Construction Materials. 2018 Dec 1;9:e00206.
[2] Gao L, Cao Y, long Liu H, xin Zhao Z, feng Ye Y, jing Fan C, zhao Zhang L, jin Tu W. Experiment and numerical study on the monitoring of super long cast-in-place pile temperature based on BOTDR technology. Measurement. 2021 Jul 1;179:109481
[3] Akinyele JO, Salim RW, Oyeti G. Use of recycled polypropylene grains as partial replacement of fine aggregate in reinforced concrete beams. Engineering Structures and Technologies. 2014 Oct 2;6(4):184-90.
[4] Gayatri D, Popat K. Use of Recycled Plastic in Concrete as Replacement of Fine Aggregate. International Research Journal of Engineering and Technology. 2020.
[5] Silva J. Real Time Temperature Monitoring: Temperature Measurement through a Thermistor Inserted into a Properly Sized Circuit using MatLab and Arduino Platforms. U. Porto Journal of Engineering. 2017 Nov 24;3(3):42-7.
[6] Akbari M, Jafari Deligani V. Data driven models for compressive strength prediction of concrete at high temperatures. Frontiers of Structural and Civil Engineering. 2020 Apr;14:311-21.
[7] Abdel-Jawad YA. Estimating concrete strength using a modified maturity model. Proceedings of the Institution of Civil Engineers-Construction Materials. 2006 Feb;159(1):33-7.
[8] Lamba P, Kaur DP, Raj S, Sorout J. Recycling/reuse of plastic waste as construction material for sustainable development: a review. Environmental Science and Pollution Research. 2022 Dec;29(57):86156-79.

[9] Warsi ZH, Irshad SM, Khan F, Shahbaz MA, Junaid M, Amin SU. Sensors for structural health monitoring: A review. In 2019 Second International Conference on Latest trends in Electrical Engineering and Computing Technologies (INTELLECT) 2019 Nov 13 (pp. 1-6). IEEE.
[10] Han Q, Ma Q, Xu J, Liu M. Structural health monitoring research under varying temperature condition: A review. Journal of Civil Structural Health Monitoring. 2021 Feb;11:149-73.
[11] Verma S, Raj V. Structural Health Monitoring Case Study Review. International Journal of Civil Engineering Research. 2017;8(1):33-8.
[12] Yavari N, Tang AM, Pereira JM, Hassen G. Experimental study on the mechanical behaviour of a heat exchanger pile using physical modelling. Acta Geotechnica. 2014 Jun;9:385-98.
[13] Utepov Y, Aniskin A, Tulebekova A, Aldungarova A, Zharassov S, Sarsembayeva A. Complex maturity method for estimating the concrete strength based on curing temperature, ambient temperature and relative humidity. Applied Sciences. 2021 Aug 21;11(16):7712.
[14] Topcu IB, Toprak MU. Fine aggregate and curing temperature effect on concrete maturity. Cement and Concrete Research. 2005 Apr 1;35(4):758-62.
[15] Mustafa MA, Hanafi I, Mahmoud R, Tayeh BA. Effect of partial replacement of sand by plastic waste on impact resistance of concrete: experiment and simulation. InStructures 2019 Aug 1 (Vol. 20, pp. 519-526). Elsevier.
[16] Zhang X, Ning S, Zhang F, Zhao L. The Research of Concrete Pile Material in Mechanical Property. In2018 7th International Conference on Energy, Environment and Sustainable Development (ICEESD 2018) 2018 May (pp. 1509-1513). Atlantis Press.
[17] Kulprapha N, Warnitchai P (2012) Structural health monitoring of continuous prestressed concrete bridges using ambient thermal responses. Eng Struct 40:20–38.
[18] Jesus A, Brommer P, Zhu Y et al (2017) Comprehensive Bayesian structural identifcation using temperature variation. Eng Struct 141:75–82.
[19] Jesus A, Brommer P, Westgate R et al (2019) Bayesian structural identifcation of a long suspension bridge considering temperature and trafc load efects. Struct Health Monit 18(4):1310– 1323.
[20] Zhu YJ, Ni YQ, Jin H et al (2019) A temperature-driven MPCA method for structural anomaly detection. Eng Struct 190:447– 458.