

## **INCORPORATING HIGH-DENSITY POLYETHYLENE AND QUARRY DUST IN CONCRETE: A SUSTAINABLE APPROACH**

**P. D. Dharmaratne<sup>1\*</sup>, R. Ravindu<sup>1</sup>, B.R.A.L Dematapitiya<sup>1</sup>, S.T.D. Gallage<sup>1</sup>, S.N. Malkanthi<sup>2</sup>,**

*<sup>1</sup> Department of Civil Engineering, Sri Lanka Institute of Information Technology, Malabe, Sri Lanka.*

*<sup>2</sup> Department of Civil and Environmental Engineering, Faculty of Engineering, University of Ruhuna, Sri Lanka*

*\*Correspondence E-mail: dhammika.dh@sliit.lk, TP: +94714342512*

**Abstract:** The construction industry faces increasing pressure to reduce natural aggregate consumption and mitigate plastic waste accumulation. This study investigates the combined utilization of waste High-Density Polyethylene (HDPE) and quarry dust (QD) as partial replacements for coarse and fine aggregates, respectively, to develop sustainable and lightweight concrete. While previous research has primarily examined the individual effects of HDPE or QD, their synergistic interaction remains insufficiently explored. An experimental program was conducted in three phases to evaluate the individual and combined influences of HDPE (5% – 100% replacement of coarse aggregate) and QD (10 %–70% replacement of river sand) on compressive strength, workability, and dry density. Results indicate that increasing HDPE content leads to a progressive reduction in compressive strength, slump, and density due to weak interfacial bonding and the low specific gravity of plastic aggregates. In contrast, QD enhances compressive strength up to an optimum replacement level of 40%, attributed to improved particle packing and interlocking. Notably, the incorporation of 40% QD significantly mitigated the strength loss associated with HDPE. With this combined approach, Grade 25 concrete was achieved with up to 36% HDPE, while Grade 15 concrete was attainable with 82% HDPE. The combination of HDPE and QD is accompanied by substantial dry density reductions of up to 16.7% compared to the control mix. The findings demonstrate that the strategic combination of HDPE and QD provides a viable pathway for producing structurally acceptable lightweight concrete while addressing plastic waste management and reducing reliance on natural aggregates. This study contributes new insights into multi-waste aggregate synergy for sustainable concrete development.

**Keywords:** High-Density Polyethylene (HDPE); Quarry Dust (QD); Compressive Strength; Lightweight Concrete; Sustainable Material

## 1. Introduction

The construction industry is identified as one of the largest consumers of natural resources highly contribute for the environment pollution (Environment, 2023). Concrete, which is the key construction material and the mostly used substance during the concrete manufacturing process (Gagg, 2014), (Shobeiri et al., 2024a). Since aggregates represent 60%-70% of the volume of concrete, global demand for natural aggregates (NAs) has increased to 4.5 billion tons per year (Abeysinghe et al., 2021). Meantime, the world is facing the challenges of managing waste materials, specifically plastic waste. Only 20% of plastic waste is properly managed (Vinod Kumar and Rupesh Kumar, 2023) and the rest are regularly landfilled or left untreated, creating to environmental pollution. Among various types of plastic waste, HDPE fails to biodegrade in natural habitats (Aocharoen and Chotickai, 2023a). QD, a byproduct of rock-crushing processes is produced in large quantities, and improper disposal leads to significant environmental hazards, including soil contamination and air pollution (AL-Kharabsheh et al., 2022). To address these environmental issues and issues related to waste management and to work towards the sustainable development goals, there has been a growing interest in the use of waste materials as partial replacements for conventional aggregates in concrete production.

While several studies have explored the use of QD or HDPE separately in concrete ((Meisuh et al., 2018a); (Kankam et al., 2017), (Abeysinghe et al., 2021)), (Gangabadaarachchi et al., 2023)..(Dharmaratne et al., 2025), there is a gap in the research data in terms of their combined effect on the properties and behaviour of concrete. Thus, this study is designed to explore the combined effect of waste HDPE and QD on concrete. This evaluates the individual and combined effects of HDPE and QD and identifies the optimum proportions that maintain compressive strength without significant compromise.

## 2. Literature Review

HDPE resulted in a reduction of mechanical properties and workability in the range of 0 to 8% in concrete (Abeysinghe et al., 2021). Abu-Saleem et al., 2021 examined the effects of substituting coarse aggregates with a mixture of plastic wastes, including PET, HDPE, and PP, at different proportions. Findings showed that the mixer of the highest plastic replacement ratio (PET 10% + HDPE 10% + PP 10%) had the lowest workability, with the decrement of the slump from 117 mm in the control mix to 86 mm. Aocharoen and Chotickai, 2023 evaluated the slump of concrete mixes containing coarse flake-shaped PET and fine pellet-shaped HDPE aggregates as replacements for natural aggregates, with volumetric replacements ranging from 0% to 10% and 0% to 34%, respectively. The study highlighted the trend of a decrease in the slump with the increment of plastic content. Conversely, Shobeiri et al., 2024 analyzed a database of concrete mixes containing coarse plastic aggregates and observed that, in most cases, with comparable water-to-binder ratios and superplasticizer content, the slump slightly increased with higher replacement percentages. Saikia and De Brito, 2012 pointed out the reduction of workability due to flakiness and porosity of plastic aggregates, while increased slump resulted from spherical-shaped plastic aggregates because of free water availability.

Siddique et al., 2008a concluded that concrete with 10%, 30%, and 50% of plastic aggregates showed a decrease of 34%, 51%, and 67% in its compressive strength. Al-Osta et al., 2022 reported a decline in strength ranging from 22% to 82% for 10% to 50% HDPE substitution. Belmokaddem et al., 2020 observed the decrease in compressive strength when replacing both fine and coarse aggregates with plastic, with the highest drop, approximately 88% observed at high HDPE replacement levels. Aocharoen and Chotickai, 2023a stated reductions in compressive strength of 21.0% and 45.0% for specimens containing 5% and 10% PET, respectively. Abu-Saleem et al., 2021 noticed a decrease in compressive strength across all plastic concrete mixes with the PET10%+HDPE10%+PP10%. Al Bakri et al., 2011 discovered that, there was a 60% decrement in the compressive strength when mixing 100% HDPE with concrete. As per Rahim et al., 2013 finding, 10% of the addition of HDPE resulted in only a 6% loss in compressive strength. Zainal and Ali, 2018 examination led to another direction where the study involved adding both fly ash with 10% HDPE, which increased the strength, but still produced a loss in strength due to the action of HDPE. Abbas et al., 2022 investigated the mechanical properties of a concrete mix with sand-coated and uncoated HDPE, showing an improvement in compressive strength in the concrete mix with sand-coated HDPE compared to uncoated HDPE.

Further, Abeysinghe et al., 2021 noticed that there is a declining pattern of workability when replacing fine aggregates from waste plastic, as a value 70 mm slump has been reduced to 30 mm as the HDPE content increased from 5% to 15% while maintaining a constant water-cement ratio. Ismail and AL-Hashmi, 2008a detected a sharp decrease in a slump up to 95% with increasing waste plastic ratios attributed to the irregular shapes of the plastic particles. Athithan and Natarajan, 2024 revealed a significant slump reduction when replacing more than 10% of fine aggregates with plastic flakes or pellets. Choi et al., 2005 reported a decrease in compressive strength of concrete from 31.5 MPa to 21.8 MPa when fine aggregates are replaced by 75% waste plastic for a water-cement (w/c) ratio of 0.53%. The same trend persisted across different w/c ratios of 0.49% and 0.45%. This trend was proved by the study done by Badache et al., 2018 by varying HDPE amounts from 0%, 50%, and 100%, where the compressive strength decreased by 53.4% and 57.8%, respectively. Ismail and AL-Hashmi, 2008a supported these findings by concluding that the particles larger in size contributed to a decrease in compressive strength. Athithan and Natarajan, 2024 also found that adding 1.5mm plastic particles increased compressive strength in concrete specimens, whereas 3 mm particles decreased compressive strength.

AL-Kharabsheh et al., 2022 observed a decline in workability when replacing fine aggregate with quarry dust. Similarly, Ponnada et al., 2020 reported a decreased slump value with 100% quarry dust replacement, where the slump height dropped from 85 mm in the control mix to 70 mm in the replacement mix. Meisuh et al., 2018a revealed a positive growth of compressive strength of concrete replacing fine aggregate by quarry at 25% and 100% by weight and noticed an increment by 2.3%, 3.54%, 9.56%, and 4.74% for C30, C35, C40, and C45 grades, respectively. Further, this fact was supported by the study conducted by Kankam et al., 2017 while AL-Kharabsheh et al., 2022 noticed that the optimal percentage of 30% and a further increment of QD reduced the compressive strength. As per the findings of studies conducted by Chitkeshwar and Naktode, 2022; Kankam et al., 2017; Meisuh et al., 2018b, compressive strength decreased when quarry dust replacement exceeded 25%, identifying 25% as the optimal fine aggregate replacement level

### 3. Materials and Methods

#### 3.1 Materials

Ordinary Portland Cement (OPC), the locally available river sand with a maximum particle size of 4.75 mm for fine aggregate, and crushed granitic-gneiss for coarse aggregate were used as the primary material in this research. The waste HDPE was used to replace the coarse aggregate partially, and QD was used as a partial replacement for fine aggregate.

The particle size distribution of the aggregate used in this study was determined by the sieve analysis, based on the standard BS EN 12620:2002 (2008). Additionally, the material's characteristics were evaluated in accordance with the standards of ASTM C330/C330M (ASTM International, 2023, p. 20) and ASTM C127 (ASTM International, 2024). The properties of materials are shown in Table 1, and the results of the sieve analysis are illustrated in Figure 1.

Table 1: Properties of Materials

Material	Bulk density (kg/m <sup>3</sup> )	Water absorption (%)	Specific Gravity
Granitic-gneiss	1,541	0.133	2.80
River sand	1,434	0.600	2.65
HDPE	354	0.010	0.95
QD	1,567	4.000	2.66

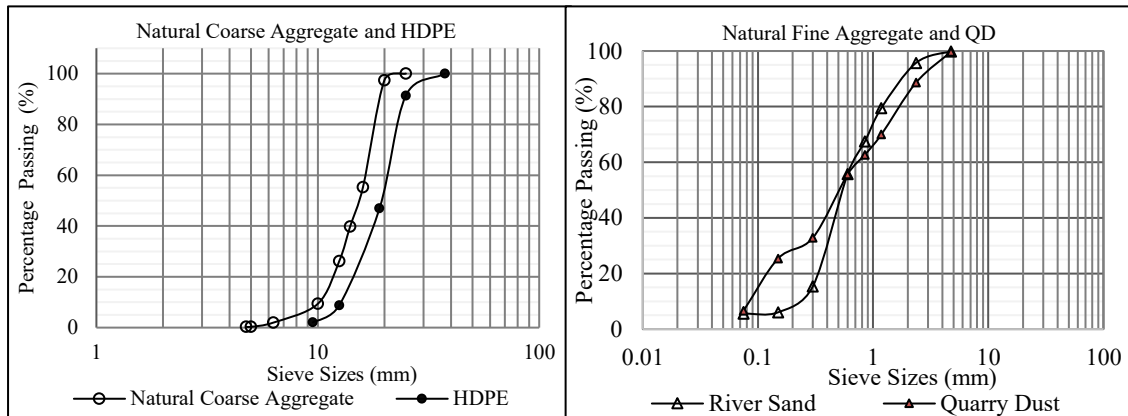


Figure 1: Particle Size Distribution.

## 2.3 Sample Preparation

The experimental setup was arranged in three stages, focusing on achieving the 28-day compressive strength of 25 N/mm<sup>2</sup>. In the first step, the test samples were prepared by replacing coarse aggregate with varying percentages of HDPE. In the second step, the test samples were prepared by replacing the fine aggregate with varying percentages of QD. Thereafter, the experiments were carried out to obtain the optimum mix design with both HDPE and QD as the third step. In this third stage, the samples were cast by replacing fine aggregate with optimum QD values based on the second-stage results. Since it was unable to get the optimum values to replace coarse aggregate with HDPE, the mix proportions were designed for varying HDPE content from 5% to 100%. The material quantities for the relevant mix design were calculated by referring to the guidelines in the Building Research Establishment method. (Building Research Establishment, 1997).

### 3.2.1 Replacement of coarse aggregate with HDPE

The concrete cubes (150 mm×150 mm×150 mm) were cast to measure the compressive strength of the concrete. In this first stage, the samples were prepared by replacing coarse aggregate with HDPE from 5% to 100% by weight at 5% intervals. Control samples were cast for comparison purposes. In this casting process, cement, river sand, and water were kept constant with a constant water-cement ratio of 0.5.

### 3.2.2 Replacement of river sand with QD

The ratio of QD to river sand was determined by studying the previous studies. According to Chauhan and Bondre 2015, the compressive strength of concrete increases with an increment of QD content up to 50%. The optimum compressive strength was observed when replacing 30% of QD with fine aggregate by Deepika et al., 2024. Further, Rani et al., 2020 found that the optimum percentage of QD was 70% to achieve the 28-day compressive strength. By referring to the above findings, this research focused on varying the QD percentage from 10% to 70% at 10% intervals to replace the river sand as the second stage.

### 3.2.3 Replacement of coarse aggregate with HDPE and river sand with QD

After obtaining the results in the above second stage, the optimum amount of QD was determined as 40%. Since the optimum HDPE content could not be identified at the first stage, it was decided to incorporate coarse aggregates in varying proportions as increments of 5% for the range of 5% to 30%, increments of 10% from 30% to 50%, and increments of 25% from 50% to 100%. Then, the test cubes were prepared without varying the other materials as the final stage.

## 4. Results and Discussion

The compressive strength test was conducted according to BS EN 12390-3 testing procedure (British Standards Institution, 2019). The slump test was carried out as per ASTM C143/C143M (ASTM International, 2015) to determine the workability of the concrete. The dry density of the concrete was determined as per ASTM C642-06 (ASTM International, 2013)

### 4.1. Compressive strength of concrete

Three replicates were tested for each mix proportion. Figure 2 illustrates the variations in compressive strength. According to the results, when HDPE increases, the 28-day compressive strength of the concrete decreases. At lower HDPE percentages, a significant reduction in compressive strength was observed. The 45% compressive strength reduction was observed within the range of HDPE from 0% to 30%. The mild gradient of the curve was observed after 30% HDPE content.

Although the mix design was prepared to achieve the 28-day compressive strength is as 25 N/mm<sup>2</sup>, the experiment results showed 32 N/mm<sup>2</sup> in the control sample. After analysing the test results, the 25 MPa compressive strength could be obtained by incorporating 24% HDPE. And also, 15 MPa compressive strength could be obtained by incorporating 58% HDPE. This declining trend has been observed by Ismail and AL-Hashmi, 2008 and stated that the reason for this reduction was due to a weaker bond between the cement slurry and the recycled plastic owing to its hydrophobic nature. Shobeiri et al., 2024 also discussed the Interfacial Transition Zone (ITZ) and its impact on the compressive strength of the concrete with plastic aggregates. They further stated that plastic aggregate consists of a smooth and less porous surface than natural coarse aggregates, which leads to a weaker bond with the cement paste. This poor interfacial bonding was discussed by Badache et al., 2018.

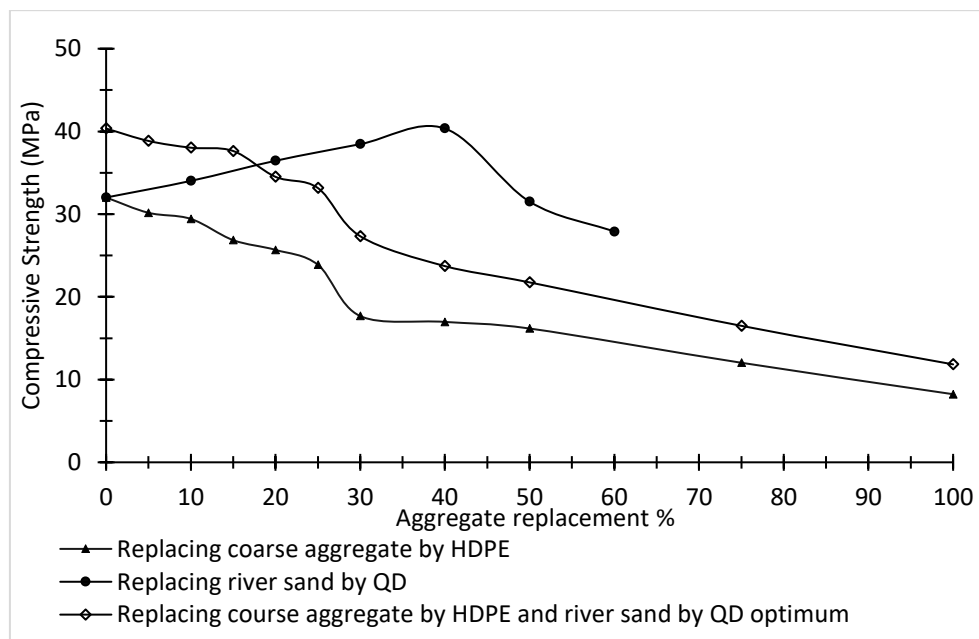


Figure 2: Compressive strength variation of concrete

When replacing river sand with QD, an increase in compressive strength was observed up to 40% QD. At 40% QD, the 40.35 MPa optimum compressive strength was observed. Beyond the 40% QD, a decrement of the compressive strength was observed. This reduction indicates that the compressive strength of concrete is negatively affected by excessive QD content. This variation is followed by previous researchers. Meisuh et al., 2018 mentioned that the optimum compressive strength could be obtained at the QD 25% to 30% range. (Kankam et al., 2017) showed that 25% to 30% QD gives optimum strength.

Thus, the optimum value for replacing river sand with QD was taken as 40%. Then the experiments were carried out to investigate the compressive strength of concrete with optimum QD and HDPE. As per the results shown in Figure 2, the increment of HDPE illustrates the decrement of the compressive strength. Similar behaviour was observed in concrete with only HDPE. However, when comparing the compressive strength of the concrete, it shows higher strength than the concrete with only HDPE.

The combination of optimum QD with HDPE resulted in approximately 25% compressive strength increment compared to the concrete with only HDPE. Therefore, it can be concluded that the combination of both materials shows more expected results than using HDPE only.

HDPE percentage can be increased up to 36% to achieve the compressive strength of concrete 25 N/mm<sup>2</sup> with 40% optimum QD. Further, it can be concluded that HDPE can be increased up to 82%, with 40% optimum QD producing the grade 15 concrete.

#### **4.2. Workability of concrete**

The workability of concrete was measured referring ASTM C143/C143M. The 100 mm slump was observed at the 24% HDPE, which gives the compressive strength of 25 N/mm<sup>2</sup>. The 50 mm slump was observed at the 58% HDPE, giving 15 N/mm<sup>2</sup> compressive strength.

However, the 50 mm slump was observed in both the 40% HDPE with optimum QD, which gives the compressive strength of 25 N/mm<sup>2</sup>, and 75% HDPE with optimum QD, giving the strength of 15 N/mm<sup>2</sup>. Similarly, this reduction in the slump of the concrete with plastic aggregate has been observed in previous studies carried out by Aocharoen and Chotickai, 2023b; Ismail and AL-Hashmi, 2008b; Shobeiri et al., 2024b; and Siddique et al., 2008b. According to their observation, this behaviour was due to the shape of the particles.

#### **4.3. Dry density concrete**

The variation of the dry density of different concrete samples was observed. The results of the concrete with HDPE and QD indicated a clear trend of declining of density with increasing of HDPE.

The density of 2,250 kg/m<sup>3</sup> was observed at the 24% HDPE, which gives the compressive strength of 25 N/mm<sup>2</sup>. It is the 6% reduction in dry density when comparing with the control sample. A density of 2,000 kg/m<sup>3</sup> was observed at the 58% HDPE, giving 15 N/mm<sup>2</sup> compressive strength. It shows the 16.7 % reduction in dry density when comparing with the control sample.

The dry density of 2,125 kg/m<sup>3</sup> was observed at the 40% HDPE and optimum QD, which gives the compressive strength of 25 N/mm<sup>2</sup>. It shows the 11.5 % reduction in density when comparing with the control sample. The dry density of 1,850 kg/m<sup>3</sup> was observed at the 75% HDPE and QD, giving 15 N/mm<sup>2</sup> compressive strength. It is the 22.9 % reduction in density when comparing with the control sample.

As previous researches have found, the plastic aggregate reduces the fresh and dry densities of concrete due to its lightweight nature, irrespective of the type and size of plastic, and due to the higher porosity of the concrete (Abeysinghe et al., 2021; Adewumi, 2018; Al-Osta et al., 2022).

As mentioned, (Al-Osta et al., 2022), (Siddique et al., 2008a) and (Belmokaddem et al., 2020), the HDPE has a lower specific gravity comparing with the conventional aggregates, which leads to the reduction in the density of concrete since there is a relationship between the density of aggregate and the density of concrete.

#### **4.4. Comparison of research findings with past research outputs**

The present study is benchmarked against a few previous studies that investigated the use of HDPE in concrete. Figure 3 illustrates the reduction in compressive strength based on the past literature data (Al Bakri et al., 2011; Habib et al., 2017, p. 201; Rahim et al., 2013; Zainal and Ali, 2018). As a summary, it can be concluded that the increasing HDPE causes to the decrease the “rate of decrement” of the compressive strength.

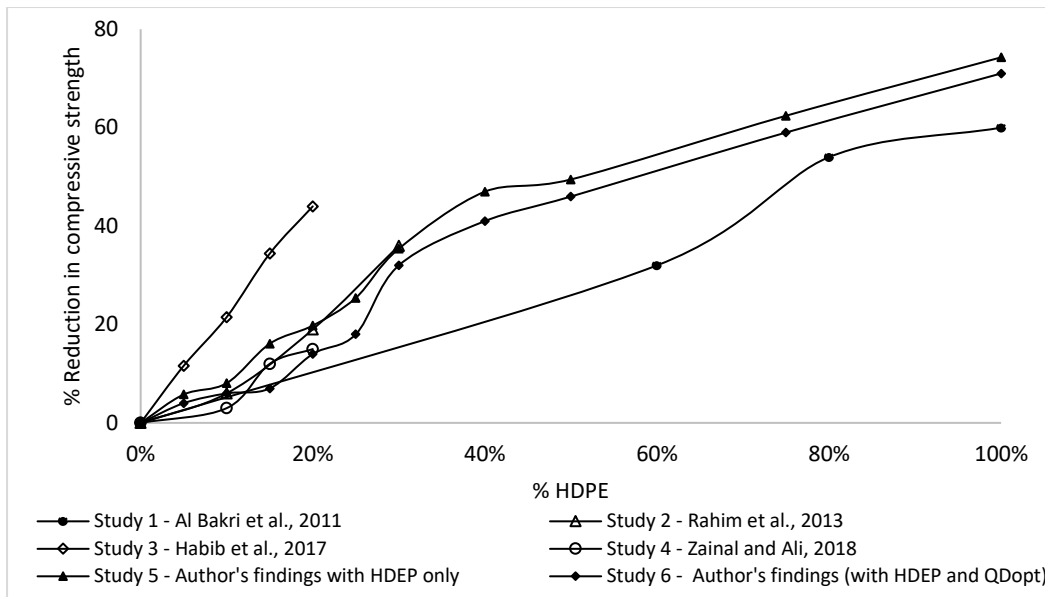


Figure 3: Compressive strength results from previous studies

## 5. Conclusion

The study successfully emphasized two types of waste materials, HDPE and QD, into concrete, contributing toward sustainable development goals. The findings highlighted the potential for producing a more sustainable concrete product through the effective utilization of waste materials, offering a better solution to the growing challenge of plastic waste disposal problems. Table 2 summarizes the main findings of the research.

Table 2: The main findings of the research

Mix design	1	2	1	2	Mix design 1 – Concrete mixed with HDPE Mix design 2 – Concrete mixed with optimum QD (40%) and HDPE
Compressive Strength (N/mm <sup>2</sup> )	25		15		
HDPE (%)	24	36	58	82	
Slump (mm)	100	50	50	50	
Dry Density (kg/m <sup>3</sup> )	2,250	2,125	2,000	1,850	
<b>Control sample</b>					
Compressive strength 25 N/mm <sup>2</sup> , Slump 175 mm, and Dry density 2,400 kg/mm <sup>3</sup>					

The findings indicated that the concrete produced only with HDPE shows a significant reduction in compressive strength and dry density. However, with 24% HDPE content gains the 25 N/mm<sup>2</sup> compressive strength showing a 6.25 % significant reduction of dry density compared to the control sample. Further, 58% of HDPE content gains the 15 N/mm<sup>2</sup> compressive strength. This concrete can be used as a secondary filling material for high-rise buildings due to its less weight by providing a solution to waste plastic disposal issues. In addition to that, this concrete can be used as a screed concrete or levelling concrete at the bottom of the shallow foundations. Even the HDPE significantly reduces compressive strength, QD causes an enhancement in the compressive strength of the concrete. However, 40% optimum QD percentage can be selected to replace fine aggregate, giving the optimum strength value. Hence, concrete was developed by varying the HDPE and a constant optimum QD percentage.

The results indicate that concrete can be produced by incorporating the optimum amount of QD with a higher proportion of HDPE, while still achieving the required strength. The HDPE content can be increased up to 36% to obtain Grade 25 concrete when combined with the optimum QD. This modified concrete exhibits a 16.7% reduction in dry density compared to the control sample. Further, the HDPE content can be increased up to 82% to obtain Grade 25 concrete when combined with the optimum QD.

This is a remarkable achievement in the plastic waste disposal problem. Hence, this finding contributes to environmental sustainability by utilizing recycled HDPE, reducing the accumulation of plastic waste, and minimizing the requirement for natural sand through QD substitution. Furthermore, this concrete can be introduced as a new sustainable construction material that minimizes use of natural resources.

While findings highlight the potential of HDPE and QD in the sustainable concrete mix, further research is necessary for assessing the long-term durability of the mix under serviceability conditions. Parameters such as water absorption, permeability, porosity, and sulphate attack should be investigated to ensure its suitability for various environmental exposures. Additionally, further investigation could be carried out to enhance the bond between the cement and HDPE, thereby enhancing the compressive strength of the concrete. Further investigation could be performed to study the sustainable criteria such as embedded energy and life cycle cost, carbon footprint etc.

### **Acknowledgements**

The authors would like to express their sincere gratitude to all the staff members of the Structural Engineering Laboratory at Sri Lanka Institute of Information Technology and the team at the plastic manufacturing plant, Polypak Secco Limited, Melfort Estate, Kaduwela, Sri Lanka, for their generous support and assistance.

## References

- Abbas, S.N., Qureshi, M.I., Abid, M.M., Tariq, M.A.U.R., Ng, A.W.M., 2022. An Investigation of Mechanical Properties of Concrete by Applying Sand Coating on Recycled High-Density Polyethylene (HDPE) and Electronic-Wastes (E-Wastes) Used as a Partial Replacement of Natural Coarse Aggregates. *Sustainability* 14, 4087. <https://doi.org/10.3390/su14074087>
- Abeysinghe, S., Gunasekara, C., Bandara, C., Nguyen, K., Dissanayake, R., Mendis, P., 2021. Engineering Performance of Concrete Incorporated with Recycled High-Density Polyethylene (HDPE)—A Systematic Review. *Polymers* 13, 1885. <https://doi.org/10.3390/polym13111885>
- Abu-Saleem, M., Zhuge, Y., Hassanli, R., Ellis, M., Rahman, M.M., Levett, P., 2021. Stress-Strain Behaviour and Mechanical Strengths of Concrete Incorporating Mixed Recycled Plastics. *J. Compos. Sci.* 5, 146. <https://doi.org/10.3390/jcs5060146>
- Adewumi, J.B., 2018. Engineering Properties of Concrete with Waste Recycled Plastic: A Review. <https://doi.org/10.3390/su10113875>
- Al Bakri, A.M., Tamizi, S.M., Rafiza, A.R., Zarina, Y., 2011. Investigation of HDPE plastic waste aggregate on the properties of concrete. *J. Asian Sci. Res* 1, 340--345.
- AL-Kharabsheh, B.N., Moafak Arbili, M., Majdi, A., Ahmad, J., Deifalla, A.F., Hakamy, A., Majed Alqawasmeh, H., 2022. Feasibility Study on Concrete Made with Substitution of Quarry Dust: A Review. *Sustainability* 14, 15304. <https://doi.org/10.3390/su142215304>
- Al-Osta, M.A., Al-Tamimi, A.S., Al-Tarbi, S.M., Baghabra Al-Amoudi, O.S., Al-Awsh, W.A., Saleh, T.A., 2022. Development of sustainable concrete using recycled high-density polyethylene and crumb tires: Mechanical and thermal properties. *J. Build. Eng.* 45, 103399. <https://doi.org/10.1016/j.jobbe.2021.103399>
- Aocharoen, Y., Chotickai, P., 2023a. Compressive mechanical and durability properties of concrete with polyethylene terephthalate and high-density polyethylene aggregates. *Clean. Eng. Technol.* 12, 100600. <https://doi.org/10.1016/j.clet.2023.100600>
- Aocharoen, Y., Chotickai, P., 2023b. Compressive mechanical and durability properties of concrete with polyethylene terephthalate and high-density polyethylene aggregates. *Clean. Eng. Technol.* 12, 100600. <https://doi.org/10.1016/j.clet.2023.100600>
- ASTM International, 2024. Standard Test Method for Relative Density (Specific Gravity) and Absorption of Coarse Aggregate [WWW Document]. URL <https://www.astm.org/c0127-24.html> (accessed 3.9.25).
- ASTM International, 2023. Standard Specification for Lightweight Aggregates for Structural Concrete [WWW Document]. URL [https://www.astm.org/c0330\\_c0330m-17a.html](https://www.astm.org/c0330_c0330m-17a.html) (accessed 3.9.25).
- ASTM International, 2015. Standard Test Method for Slump of Hydraulic-Cement Concrete [WWW Document]. URL [https://www.astm.org/c0143\\_c0143m-12.html](https://www.astm.org/c0143_c0143m-12.html) (accessed 3.8.25).
- ASTM International, 2013. Standard Test Method for Density, Absorption, and Voids in Hardened Concrete [WWW Document]. URL <https://www.astm.org/c0642-06.html> (accessed 3.8.25).
- Athithan, V., Natarajan, L.T., 2024. Performance of Various Forms of Plastic Waste as a Resource for Construction Material. *J. Hazard. Toxic Radioact. Waste* 28, 03123006. <https://doi.org/10.1061/JHTRBP.HZENG-1252>
- Badache, A., Benosman, A.S., Senhadji, Y., Mouli, M., 2018. Thermo-physical and mechanical characteristics of sand-based lightweight composite mortars with recycled high-density polyethylene (HDPE). *Constr. Build. Mater.* 163, 40–52. <https://doi.org/10.1016/j.conbuildmat.2017.12.069>
- Belmokaddem, M., Mahi, A., Senhadji, Y., Pekmezci, B.Y., 2020. Mechanical and physical properties and morphology of concrete containing plastic waste as aggregate. *Constr. Build. Mater.* 257, 119559. <https://doi.org/10.1016/j.conbuildmat.2020.119559>
- British Standards Institution, 2019. BS EN 12390-3 [WWW Document]. pdfcoffee.com. URL <https://pdfcoffee.com/bs-en-12390-3-5-pdf-free.html> (accessed 3.4.25).
- Building Research Establishment, B.R.E., 1997. BRE Concrete mix design method [WWW Document]. URL <https://www.concrete.org.uk/fingertips-nuggets.asp?cmd=display&id=435> (accessed 3.4.25).
- Chauhan, S.L., Bondre, R.A., 2015. Partial Replacement of Sand by Quarry Dust in Concrete 5.
- Chitkeshwar, A.K., Naktode, P.L., 2022. Concrete with rock quarry dust with partial replacement of fine aggregate. *Mater. Today Proc.* 62, 6455–6459. <https://doi.org/10.1016/j.matpr.2022.04.195>

- Choi, Y.-W., Moon, D.-J., Chung, J.-S., Cho, S.-K., 2005. Effects of waste PET bottles aggregate on the properties of concrete. *Cem. Concr. Res.* 35, 776–781. <https://doi.org/10.1016/j.cemconres.2004.05.014>
- Dharmaratne P.D, Galabada G. H., Malkanthi S. N., and Halwatura R. U., “Waste Polyethylene Reinforced with Coconut Fibers for Sustainable Construction: A Mechanical and Physical Property Evaluation Study”, *Eng. Technol. Appl. Sci. Res.*, vol. 15, no. 5, pp. 28136–28143, Oct. 2025.
- Dharmaratne P.D., R M C D Madawala, Galabada H.G, and S.N.Malkanthi “Eco-Friendly Composite Ceiling Material from Low -Density Polyethylene and Coconut Fibre” FIDIC Asia Pacific Conference: New Technologies Transforming Engineering and Construction Industry, Bali, Indonesia, 2025
- Deepika, K., Prasad, B.V., Yuvateja, K., Babu, P.N., Kopuri, N.A.G.K.M., 2024. A Study on Concrete with Quarry-Dust as Partial Replacement to Fine Aggregate. *Int. J. Eng. Res. Technol.* 13. <https://doi.org/10.17577/IJERTV13IS030055>
- Environment, U.N., 2023. Building Materials And The Climate: Constructing A New Future | UNEP - UEnvironment Programme URL <https://www.unep.org/resources/report/building-materials-and-climate-constructing-new-future> (accessed 2.2.25).
- Gagg, C.R., 2014. Cement and concrete as an engineering material: An historic appraisal and case study analysis. *Eng. Fail. Anal.* 40, 114–140. <https://doi.org/10.1016/j.engfailanal.2014.02.004>
- Habib, M.Z., Alom, M.M., Hoque, M.M., 2017. Concrete production using recycled waste plastic as aggregate. *J. Civ. Eng. IEB* 45, 11--17.
- Ismail, Z.Z., AL-Hashmi, E.A., 2008a. Use of waste plastic in concrete mixture as aggregate replacement. *Waste Manag.* 28, 2041–2047. <https://doi.org/10.1016/j.wasman.2007.08.023>
- Gangabadaarachchi S.N., Harsha Galabada, Dharmarathne P.D., .Malkanthi and R.U.Halwatura “Waste polyethylene with Kithul fiber as a composite material”, 9th International Symposium, University of Ruhuna, 2023
- Ismail, Z.Z., AL-Hashmi, E.A., 2008b. Use of waste plastic in concrete mixture as aggregate replacement. *Waste Manag.* 28, 2041–2047. <https://doi.org/10.1016/j.wasman.2007.08.023>
- Kankam, C.K., Meisuh, B.K., Sossou, G., Buabin, T.K., 2017. Stress-strain characteristics of concrete containing quarry rock dust as partial replacement of sand. *Case Stud. Constr. Mater.* 7, 66–72. <https://doi.org/10.1016/j.cscm.2017.06.004>
- Meisuh, B.K., Kankam, C.K., Buabin, T.K., 2018a. Effect of quarry rock dust on the flexural strength of concrete. *Case Stud. Constr. Mater.* 8, 16–22. <https://doi.org/10.1016/j.cscm.2017.12.002>
- Meisuh, B.K., Kankam, C.K., Buabin, T.K., 2018b. Effect of quarry rock dust on the flexural strength of concrete. *Case Stud. Constr. Mater.* 8, 16–22. <https://doi.org/10.1016/j.cscm.2017.12.002>
- Ponnada, S., Sankar Cheela, V., Gopala Raju, S., 2020. Investigation on mechanical properties of composite concrete containing untreated sea sand and quarry dust for 100% replacement of fine aggregate. *Mater. Today Proc.* 32, 989–996. <https://doi.org/10.1016/j.matpr.2020.06.203>
- Rahim, N.L., Sallehuddin, S., Ibrahim, N.M., Amat, R.C., Ab Jalil, M.F., 2013. Use of Plastic Waste (High Density Polyethylene) in Concrete Mixture as Aggregate Replacement. *Adv. Mater. Res.* 701, 265–269. <https://doi.org/10.4028/www.scientific.net/AMR.701.265>
- Rani, B.S., Reddy, L.R.P., Reddemma, S., Chandra, Ch.D., Ranganathan, A., 2020. An Experimental Study on Quarry Dust as Partial Replacement for Sand in Concrete. *Int. J. Innov. Res. Comput. Sci. Technol.* 8, 459–465. <https://doi.org/10.55524/ijirest.2020.8.6.18>
- Saikia, N., De Brito, J., 2012. Use of plastic waste as aggregate in cement mortar and concrete preparation: A review. *Constr. Build. Mater.* 34, 385–401. <https://doi.org/10.1016/j.conbuildmat.2012.02.066>
- Shobeiri, V., Bennett, B., Xie, T., Visintin, P., 2024a. A comprehensive data driven study of mechanical properties of concrete with waste-based aggregates: Plastic, rubber, slag, glass and concrete. *Case Stud. Constr. Mater.* 20, e02815. <https://doi.org/10.1016/j.cscm.2023.e02815>
- Shobeiri, V., Bennett, B., Xie, T., Visintin, P., 2024b. A comprehensive data driven study of mechanical properties of concrete with waste-based aggregates: Plastic, rubber, slag, glass and concrete. *Case Stud. Constr. Mater.* 20, e02815. <https://doi.org/10.1016/j.cscm.2023.e02815>
- Siddique, R., Khatib, J., Kaur, I., 2008a. Use of recycled plastic in concrete: A review. *Waste Manag.* 28, 1835–1852. <https://doi.org/10.1016/j.wasman.2007.09.011>

- Siddique, R., Khatib, J., Kaur, I., 2008b. Use of recycled plastic in concrete: A review. *Waste Manag.* 28, 1835–1852. <https://doi.org/10.1016/j.wasman.2007.09.011>
- Vinod Kumar, R., Rupesh Kumar, D.D., 2023. Recycled plastic (HDPE) coarse aggregate manufacturing method and performance in concrete. *Mater. Today Proc.* 92, 1304–1309. <https://doi.org/10.1016/j.matpr.2023.05.489>
- Zainal, S.H., Ali, S., 2018. Effect of Fly Ash And HDPE On Concrete Strength. *Politeknik \& Kolej Komuniti Journal of Engineering and Technology* 3, 81--89.