Feasibility Study of using Industrial Waste as an Internal Curing Aggregate for Rigid Pavements

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Abstract

The hydration process of cement in concrete affects the temperature conditions and moisture content which indirectly cause for strength, shrinkage and cracks. Curing starts immediately after setting of concrete. American Concrete Institute describes curing as "action taken to maintain moisture and temperature conditions in a freshly placed cementitious mixture to allow hydraulic-cement hydration and, if applicable, pozzolanic reactions to occur so that the potential properties of the mixture may develop". In external curing of rigid pavements, water inside the concrete consumed for hydration of cement, some part of water escapes to the atmosphere through concrete surface and some part absorbs to the ground. Thus. Internal drying occurs which reduces the relative humidity while increasing the internal stresses which results in shrinkage and thermal cracks. External supplied water will only affect for top part of the concrete layer.

Internal curing method has been introduced as a solution to the problems encountered in external curing. According to American Concrete Institute, they defined internal curing as "a process by which the hydration of cement continues because of the availability of internal water that is not part of the mixing water". It's a method which supply water internally through water reservoirs which need for hydration process. This research is to develop a fine aggregate for rigid pavements which performs the internal curing properties using industrial waste. Water treatment sludge (WTS) and Textile Effluent sludge (TES) used as industrial waste to prepare fine aggregates. After several steps in treatment process to remove inorganic, organic contaminants and suspended solid particles in surface water, produce large quantities of sludge by removing impurities from raw water. Sludge removed from above process called 'water treatment sludge'. Textile industry consume large amount water to convert raw materials and fabric to finished clothing materials. Specially for dyeing. So large quantity of sludge produces in the waste water treatment plants due to this case. The disposal of sludge from water treatment plants and textile dyeing industry is a huge issue for related authorities. Introduce a value-added product for waste sludge will be another solution for the waste. The water treatment sludge and textile effluent sludge was dried under sunlight and crushed in to powder form which passing through 0.6mm sieve. Thermogravimetric analysis and Differential scanning calorimetry are conducted to identify the thermal behaviour of sludges. Different mixtures were prepared by changing two sludge contents (100% WTS, 90% WTS+10%TES, 80%WPS+20%TES). Atterberg limits was initially identified to select the optimum water content need to mix the samples. For laboratory tests, cylindrical samples (Height; 80mm, Diameter; 17mm) were prepared for heating process. Slow heating method used to sinter the samples for different temperature levels (800^{0}C, 900^{0}C, 1000^{0}C, 1100^{0}C, 1200^{0}C). Then samples were crushed to small particles which passes through 4.75mm sieve and retained on 0.6mm sieve. Water absorption test, Relative density test, bulk density test was conducted to observe the physical properties of developed fine aggregates. Scanning Electron Micrographs (SEM) analysis was followed to observe the microstructure of the fine aggregates. Compressive strength test was followed to identify which temperature shows the higher strength of fine aggregates. According to ASTM C1761M, internal curing aggregate shall have a 72-h absorption not less than 5%. Also, the fine aggregate shall release at least 85% of its absorbed water at 94% relative humidity. When Kelvin equation combined with Young's equation, a relationship between relative humidity and size of the pores being is established. According to the relationship, the pore size should be more than 200nm to release water from aggregate.

The fine aggregates which developed using sludge waste shows higher water absorption which need for internal curing property. According to the SEM analysis, it shows that the pore size increases with the temperature and textile effluent sludge content. According to thermogravimetric analysis, compressive strength test and microstructure, it concludes that 1150^{o}C is the optimum temperature to heat the sludge waste. The optimum textile effluent sludge and water treatment sludge were selected as 20% and 80% respectively, while 45% of water content should be added when preparing the mixture. As a conclusion to the above findings, the fine aggregates which developed using sludge waste feasible to use as an internal curing aggregate in rigid pavements.

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