**Kaunas University of Technology**

Civil Engineering and Architecture Faculty

# Cement systems containing dry sludge from waste water concrete plants

Master's Final Degree Project

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Structural and Building Products Engineering (6211EX008)

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## Declaration of Academic Integrity

I confirm that the final project of mine, Jihad Alobeid, on the topic „ Cement systems containing dry sludge from waste water concrete plants“ is written completely by myself; all the provided data and research results are correct and have been obtained honestly. None of the parts of this thesis have been plagiarised from any printed, Internet-based or otherwise recorded sources. All direct and indirect quotations from external resources are indicated in the list of references. No monetary funds (unless required by law) have been paid to anyone for any contribution to this project.

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(name and surname filled in by hand) (signature)

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## Summary

Binders hold a big amounts of supplementary cementing materials (SCM) have been a subject of interest for many years. So it is possible to decrease the amount of Portland cement in binder composition, and in consequence reduce the negative influence of cement production on the environment. Reducing the consumption of Portland cement with simultaneous recycling by-product materials is important to eschew wastage and the environmental problem.

This work connected with the using of the dry sludge from waste water concrete plants for fabricate the hardened cement paste and concrete specimens. X-ray powder diffraction, survey the electronic microscopy, energy-dispersive X-ray spectroscopy, the porosity and flexural strength of full absorption water and density as investigation methods was used. The compressive strength of specimens was measured at day 7 and 28.

In the first chapter it was shown that the addendum of sludge reduced the compressive strength of hardened cement paste at both 7 and 28 days. In the hardened cement paste specimen by substituting of Portland cement with 5 - 30% of sludge the compressive strength decreases. The zeolitic and sludge waste blended Portland cement containing up to 10% of supplementary cementing materials SCM obtained a big average or similar compressive strength as the reference specimen after 28 days, while higher replacement levels lead to a downsizing in compressive strength.

In the second chapter concrete specimens were investigated. It were chosen 4 types of diferent composition by changing the contain of zeol and Portland cement with sludge (5%, 10% and 20%). Supplementary cementing materials impact the compressive strength of concrete specimens. After 28 days of hydration Specimens with 5% of sludge and 5% of zeolitic waste had for 3.3 % higher compressive strength than reference specimens. The flexural strength of concrete specimens slightly decreased by increasing the amount of SCM. By increasing the amount of supplementary cementing materials (SCM) in the composition of concrete specimens the frost resistance slightly increased after 28 days of hardening.

Jihad Alobeid. Cemento sistemos, Kuriose yra betono gamyklu nuotekinio vandens sauso dumblo. Bakalauro baigiamasis projektas / vadovė doc. dr. Danutė Vaičiukynienė; Statybos ir architektūros fakultetas, Ekonomikos ir verslo fakultetas.
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## Santrauka

Rišikliai, turintys didelį kiekį cemento pakaitinių medžiagų, buvo aktuali tyrinėjimų sritis daugelį metų. Tokiu būdu, naudojant cemento pakaitines medžiagas galima sumažinti portlandcemenčio kiekį rišiklio sudėtyje ir dėl to sumažinti neigiamą cemento gamybos įtaką gamtai ir aplinkai. Gerinant aplinkosaugos būklę ir taupant medžiagas, svarbu sumažinti portlandcemenčio vartojimą, o tuo pačiu metu vietoj jo panaudoti perdirbtus antrinius gamybos produktus.

Šis darbas buvo susijęs su betono gamyklų nuotekų sauso dumblo naudojimu, cementiniame akmenyje ir betono bandiniuose. Darbe buvo panaudoti tokie tyrimo metodai: rentgenografija (XRD), skenuojanti elektroninė mikroskopija, rentgeno fluorescencinė analizė, vandens absorbcija ir poringumo nustatymas bei lenkimo ir gniuždymo stiprių nustatymas. Cementinio akmens ir betono bandinių mechaninės savybės buvo nustatytos po 7 ir 28 parų.

Pirmajame skyriuje buvo tirta minėto dumblo įtaka cementinio akmens savybėms. Nustatyta, kad didinant dumblo kiekį 5–30% bandiniuose stipris gniuždant mažėjo ir po 7 ir po 28 parų. Naudojant ir dumblą, ir ceolitinę atlieką vietoj portlandcemenčio buvo gauti ženkliai geresni stiprio gniuždant rezultatai. Naudojant minėtų 5% pakaitinių medžiagų buvo gautas didesnis stipris gniuždant, o keičiant portlandcementį 10% dumblo - bandinių stipriai buvo artimi kontrolinių bandinių stipriams po 28 parų kietėjimo. Didesnio nei 10% dumblo ir ceolitinės atliekos kiekio panaudojimas sumažino gniuždymo stiprį.

Antrajame skyriuje buvo ištirti betono bandiniai. Buvo pasirinktos 4 skirtingos sudėties bandiniai, pakeičiant juose 5%, 10% ir 20% portlandcementį dumblu ir ceolitine atlieka. Cemento pakaitinės medžiagos paveikė betono bandinių stiprumą. Po 28 parų hidratacijos bandiniai, kuriuose buvo 5% dumblo ir 5% ceolitinės atliekos, turėjo 3,3% didesnį gniuždymo stiprį nei kontroliniai bandiniai. Betono bandinių stipris lenkiant neženkliai mažėjo, didinant cemento pakaitinių medžiagų kiekį. Didinant cemento pakaitinių medžiagų kiekį, betono bandinių sudėtyse, atsparumas šalčiui šiek tiek padidėjo po 28 dienų sukietėjimo.

# Introduction

This project is talking about the procedure of using dry sludge from waste water concrete plants for producing the fresh concrete, this idea will decrease the usage of water and help the environment, the using of sludge from waste water is a process that helps protect our planet and all the creatures living on it, including you! A cleaner future is possible, but it will have to start with a new approach to an old problem.

The chemistry of waste water reflects human activities. Industrial, agricultural, and municipal activities are represented by the waste water produced in each. Due to its value and scarcity, waste water is treated, discharged to a receiving stream, and withdrawn for reuse by the downstream population. Consequently, the chemical and bacteriological composition must be monitored to ensure the public health.

Indirect use poses the same health risks as planned waste water use projects but may have a greater potential for health problems because the water user is unaware of the waste water being present. Indirect use is likely to expand rapidly in the future as urban population growth outstrips the financial resources to build adequate treatment works. Where indirect use occurs, the primary objective must also be to ensure that it is in a manner than minimizes or eliminates potential health risks.

The lab work will use the sludge to make the hardened cement pastes and concrete specimens. sludge will be as an alternative material of cement powder, with different amount or continue of sludge during make the specimens.

Cement is a fine mineral powder manufactured with very precise processes. Mixed with water, this powder transforms into a paste that binds and hardens when submerged in water. Because the composition and fineness of the powder may vary, cement has different properties depending upon its makeup.

## Aim of the work

The aim of this work: to determine the mechanical, mineralogical and physical properties of hardened cement pastes and concrete specimens by using zeolitic waste and sludge from waste water concrete plants as cement supplementary material.

**Objectives:**

- To determine the density and compressive strength and flexural strength of hardened cement paste with sludge or with sludge and zeolitic waste .
- To evaluate the influence of sludge and zeolitic waste on the mechanical and physical properties of concrete.
- To determine of supplementary cementing materials (sludge and zeolitic waste) in fluence on the frost resistance of concrete specimens.

# 1. Literature summary

## 1.1. The effect of zeolite on the hardened cement paste

The accompanying trial utilized distinctive properties including manufactured zeolite (modification A) which were acquired in a research facility by low-temperature blend (underneath 105 °C). as indicated by the mind boggling zeolite admixture was cultivated with a blend of aluminum hydroxide $Al(OH)_3$ and Aluminum fluoride ($AIF_3$) generation squander and also sodium hydroxide NaOH. The durability of the cement paste was vitally affected by the engineered zeolite admixture as revealed by Girskas [1].

Nagrockiene et al. [2] expressed that utilizing $CaCl_2$ for modification, the waste created by the $AIF_3$(amorphous $SiO_2$), and the NaOH and $Al(OH)_3$ by low-temperature (105 °C) combination, the examination of the manufactured zeolite can happen. The altered zeolite impact on the de-icing salt obstruction of the solidified cement paste and stop defrosting and was tried by trading the zeolite added substance with 5 percent and 10 percent of the cement mass in the concrete. Uneven stop defrost cycles were utilized with samples of an answer made of 3% NaCl which was on the best surface. Every seven cycles of freeze-thaw included tests of the scaled material content, the elongation of the specimens as well as the ultrasonic pulse velocity. Inner and surface diffraction designs for X - rays have been gotten and analyzed. There was a significant improvement in the resistance of freeze-thaw and de-icing. The progressions of the microstructure for cement glue and additionally the cement hydration item brought about de-icing salt obstruction and stature solidify defrost. Poetical porosity has been lower, the substance of aluminum hydrates and calcium silicate has been expanded by diminishing the substance of $Ca(OH)_3$ in the solidified cement paste. Because of the hardened cement paste, which contains manufactured zeolite added substances affirmed by SEM image, a denser structure of various morphologies was gotten. The synthetic zeolite might be utilized as an added substance for high freezing and de-icing cement items with salt opposition (concrete, mortar).

Vaitkevičius [3] announced the pleasing cementitious materials in the cement and concrete industry, zeolites are a correct decision. The engineered of the zeolites is utilized as valuable materials inside the hardened cement paste, and thusly, the properties affecting Portland cement hydration was determinate. Through the studding strategies, X-ray powder diffraction, vitality dispersive X-ray spectroscopy and examining electron microscopy and FTIR spectroscopy were utilized. The instrumental examination demonstrated that unreacted $Al(OH)_3$ remains and zeolite A(Na) commands in explored synthetics zeolites, comprised of thermal and mechanical treated $AlF_3$ production waste. The Chapelle test censured that the two zeolites have great pozzolanic properties.

Normally zeolite choice, for example, superfine zeolites (SPZ) is because of the higher degree of fineness when contrasted with cement. As a pozzolanic material, it might supplant cement bringing about a decrease in the utilization of cement and the carbon impression of concrete generation. To assess the impacts of SFZ on strength and other properties, 30 cement paste mixture with various SFZ substance and W/CM ratio were tested in the accompanying way: 7-day, 28-day, 70-day strength tests, and flow and cohesion tests. The assessment of the adequacy of superfine SFZ filler and additionally changes in the packing density and water film thickness (WFT) were tried. A decline of 20% in the early strength was found with the expansion of SPZ, anyway by and large strength demonstrated an expansion. On that we include, the packaging density was expanded, and its impact on the fresh properties of cement paste was spend by the comparing change in the WFT. It cause an expanding in the cohesiveness with a similar flowability significantly. the extended perlite occur as a lightweight and profitable material inside agribusiness and agriculture and for customary building materials industry. Amid the generation and preparing of extended perlite, squander perlite (fine) are made. The low bulk density qualities cause squander stretched out perlite testing to deal with, and make dust arrangement. A strategies for legitimate usage is introduced by the paper of waste extended perlite which thusly give it an important and high performance pozzolanic cementitious material. To crush cell microstructure of waste extended perlite a ball process was utilized. Results demonstrated a significant increment in the material surface territory and also strength gain by up to half% (for 35% expansion in concrete mass). The high activity ground waste can be used as a substitute as well as an additive depending on the desired properties of final material as well as the pozzolanic activity of the debris was reported. A decrease of calcium hydroxide was demonstrated by ground extended perlite response in the light paste. The generally utilized business pozzolanas was contrasted and The pozzolanic action of ground waste extended perlite. These outcomes let further arrangement in of the pozzolanic properties. It tends to be an imperative extra cement material for its action and its splendid white shading. Utilizing it as a surrogate to cement gives a chance to decrease carbon dioxide emanation, because of the broad discharges previously delivered by Portland concrete as written in Chen [4].

Özen [5] expressed the compressive quality, protection from acidic conditions, chloride particle dispersion, protection from acidic situations and water retention cause the zeolite at extents of 10% and 15% of fastener and tuff at proportions of 5%, 10% and 15% of the fine total. The outcomes impressive increments in stuff and compressive strength. The more tuff content in the concrete, the more grounded it was, the further enhancement when contrasted with simply concrete. Water absorption results showed less absorption too. Noteworthy improvement happened while consolidating tuff and zeolite. 10% zeolite and 15% tuff separately are the great alternatives while considering needing to bring down chloride diffusion and water absorption. By and by, the absorption trademark and calcareous diminished the resistance to acid attacks in the tuff.

Two common zeolites were calcined at various temperatures to watch qualities making them a cement substitute. When calcination, the natural zeolites were initially portrayed for their crystallinity by X-ray diffraction analysis, pozzolanic, and nitrogen absorption movement by electrical conductivity strategy. To survey the natural zeolite as correct cement substitutions, the mixed mortars and Portland cement paste with calcined zeolites and raw were tried for their water necessity, free lime content, pore estimate dispersion, and compressive strength. The outcomes showed it was progressively alluring with lower water prerequisite and higher strength execution when contrasted with the raw zeolites. The natural zeolite likewise demonstrated an expansion in compressive strength performance, when contrasted with that with the untreated zeolite as supported by Küçükyıldırım [6].

High pozzolanic action of the synergist splitting impetus spent on deposits (FCC) was accounted for. Be that as it may, no write about the lime obsession blended with other pozzolan has been given. One option is to consolidate and fly fiery remains the sample. The advantage includes:

1) FCC generation is fly ash (FA) pozzolans with low compared.

2) The FCC reacts to short healing times while the FA reacts longer.

3) The FCC has hard water, and the FA tends to improve the binder fluidity.

For restored paste of 3-365 days, the advancement of pastes was observed utilizing thermogravimetric examination. The pozzolanic response items were distinguished by SEM, some of them including cubic precious stones ($C3AH_6$ or potentially hydro garnet). An expansion in %FCC by, the measure of the calcium aluminate hydrates (CAH) and calcium aluminosilicate hydrates (CASH) additionally expanded as detailed by Velázquez [7].

Wilińska [8] expressed that the binders had been a subject of enthusiasm for a long time in view of the conceivable decrease in concrete cement. The goal was to examine fly ash-cement systems by including an aluminosilicate impetus utilizing systems such, for example, calorimetry and warm investigation as the essential research strategies. The impetus has been appeared to quicken the early moisturization of the binder. It is invaluable not to utilize in excess of 10 percent of this spent catalyst all together not to change the hydration instruments. Because of the quick utilization of $Ca(OH)_2$, it is proposed that the organization of binders be changed by including extra measures of $Ca(OH)_2$ or cement.

The catalyst disposed of from FCC units of substantial oil portions regularly indicated high groupings of silica and alumina, which thusly enabled it to be utilized as a pozzolanic material. The action of a spent FCC catalyst from a Brazilian refinery oil was assessed by concentrate the impact of the substitution of a type II cement in various degrees. Thermogravimetry (TG), subordinate thermogravimetry (DTG) and non - customary differential warm examination (NCDTA) were utilized to assess pozzolanic activity. The outcomes demonstrated that the chemical pozzolanic movement is improved when the sample is at a higher explicit surface as composed by Cunha [9].

Burris [10] detailed the impacts of the utilization of treating nine acid solution of characteristic clinoptilolite zeolite, 0.1 M, 0.5 M, or 1 M hydrochloric or nitric corrosive or 0.1 M, 0.5 M, or 0.87 M acetic acid. They were estimated utilizing x-ray diffraction, investigation of molecule measure, examination of the surface zone and circulation of pore size. The pozzolanic reactivity was assessed following 28 and 90 days by estimating the measure of portlandite. The outcomes demonstrated an expansion in the zeolite surface region in all situations, prompting expanded reactivity. Hydration of cement has additionally been made strides. The carbonation of cement with clinoptilolite and silica fumes is contemplated in the primary minutes up to the 24th hour of hydration. Calcite crystallization at first glance happens straightforwardly between the arrangement calcium ions and air $CO_2$ without portlandite and ettringite development. The crystallite size of calcite is around 50–60 nm up to 120 min and afterward brings down to 480 min (20– 30 nm). The clinoptilolite mixture demonstrates a moderate procedure of gypsum disintegration. The thermal reactions between 480 and 700 ° C are identified with the lack of hydration decarbonization of the unsteady, incompletely crystallized Ca-carbonates. In the range 700– 850 °C the headliner is deterioration of stable carbonate stages as revealed by Lilkov [11].

Lyu [12] expressed that the self- desiccation is a typical wonder of high - execution cement materials with low water to cement ratio (w / c). Autogenous shrinkage is firmly connected to the decline in relative internal humidity (RH) and the slender weight in cement pastes caused by self-desiccation. Nonetheless, the time-zero assurance is talked about when autogenous shrinkage starts to create. The goal of the investigation is to give an exact time-zero examination dependent on the connection between interior HR and the autogenous decrease of low w/c concrete pastes. What's more, zeolite-mixed cement pastes were set up to look at the capability of zeolite as an inside recuperating specialist in time zero. Autogenous shrinkage was done by the standard ASTM C1698 methode. internal RH was completed right on time with the traditional hygrometer methode on the fixed cement pastes. The set time was resolved by the ASTM C191 standard methode by the Vicat needle device. Trial results demonstrated that amid the last Vicat setting time no internal RH drop was watched. Moreover, a knee point in the shrinkage bend was noted when the internal HR started to decline. This is the so-called zero time, and zeolite has been observed to be a potential interior recuperating specialist estimated from the new time zero by the autogenous shrinkage tests.

Mola-Abasi [13] detailed the enhancement of neighborhood soils with cement and zeolite being exceptionally helpful, including the fortifying of slants in issues of slant stability and the adjustment of dangerous soils to avoid liquefaction. Portion approaches for enhanced soils have been as of late created specifically innovation from an objective standard. This investigation plans to measure the amount of cement, zeolite, porosity and recuperating time in the assessment of the obscure compressive force (UCS) of established sand mixture. Vacuum proportions, cement content, zeolite substance and fix times were performed in this paper. The outcomes demonstrate that the UCS estimations of samples increment significantly to an ideal measure of 30 percent following 28 days of mending time with an expanded zeolite content. The rate of enhancement is roughly 20 to 80% and 20 to 60% for 28 and 90 days of recuperating time. Besides, the polynomial models are appropriate for the estimation of UCS estimations of zeolite-curated blends. The affectability investigation likewise uncovers the parameter effect on the polynomial model and the commitment of every coefficient. The substance of cement and zeolite is all the more firmly connected between relative thickness and time of mending.

Perraki [14] expressed in this work, the impact of zeolite, originating from Pentalofos territory, Thrace, Greece, on the hydration of cement is analyzed. The trial part comprises of three stages: a total mineralogical portrayal of the zeolite was done in the main stage. Moreover, the pozzolanic reactivity of zeolite was surveyed utilizing the Chapelle test. Pastes of Portland cement with 0 percent, 10 percent, 20 percent and 30 percent by load of fine zeolite were set up in the second stage. The pastea was water recuperated for 1, 2, 7 and 28 days at 20°C. In blend with thermoanalytical strategies (TG/DTG and differential thermal analysis), the hydration rate and the items were at last considered utilizing X-ray diffraction, and Fourier changes infrared spectroscopy. As finished up, the zeolite inspected is prevalently " heulandite type II " and indicates great pozzolanic reactivity (0.555 g $Ca(OH)_2$ per gram of zeolite, as per the Chapelle test). The incorporation of zeolite in cement adds to the utilization of $Ca(OH)_2$ shaped amid the hydration of cement and the arrangement of hydrated cement like items.

Natural zeolite is a mineralogical material that contains a lot of $SiO_2$ and $Al_2O_3$ receptive material. It is generally utilized as a cement mixing material in China's cement industry. Like other pozzolanic materials, for example, silica fume and fly ash, zeolite primarily adds to concrete strength through the pozzolanic response with $Ca(OH)_2$, so the pozzolanic reactivity of this sort of material is of extraordinary enthusiasm for correlation with different pozzolans. Test results on compressive strength, the degree of pozzolanic response and porosity of zeolite changed cement pastes are introduced in this paper. These outcomes are contrasted and those acquired from correspondingly mixed cement pastes produced using silica fumes and ash replacements. In view of the trial discoveries, it tends to be inferred that natural zeolite is a pozzolanic material with a reactivity between silica fume and ash fly. All in all, the natural zeolite contributes more to the strength of pastes in mixed cement pastes with a lower proportion of water to cement materials. Be that as it may, in the pastes with a higher water to cementitious ratio and a lower cement substitution level it experiences a higher degree of reaction as composing by Poon [15].

The goal of this investigation is to analyze the physical, chemical, mechanical and microstructural properties of mortars created by clinoptilolite, a zeolite mineral found inexhaustibly in nature, in Portland cement with increasing ratios It was seen that plasticizer times change as per the clinoptilolite mix ratios of mixed cement and that early strengths shift as indicated by Blaine values. It was additionally discovered that a definitive strengths create in extent to the receptive $SiO_2$ and clinoptilolite particle trade limit contingent upon the CH level in the medium. As announced by Yılmaz [16].

Perraki [17] revealed in this paper the properties and the hydration of cement containing natural zeolite, originating from the Metaxas zone, Thrace, Greece, are contemplated. The preliminary part comprises of three phases. An entire mineralogical portrayal of the zeolite was done in the main stage. The pozzolanic reactivity of the zeolite has likewise been evaluated from the Chapelle test. The mechanical and physical properties of mixed cement, including 10 percent and 20 percent fine zeolite weight, were resolved in the second stage. At long last, X-ray diffraction and FTIR spectroscopy joined with thermoanalytical methods (TG/DTG and DTA) were utilized to think about the hydration rate and the items. As finished up, the zeolite analyzed comprises fundamentally of heulandite type II and is a pozzolanic material that adds to the improvement of the quality of zeolite-cement mixtures, the utilization of $Ca(OH)_2$ in Portland cement hydration and the development of hydrated cement like items. At long last, the expansion of zeolite up to 20 percent w/w does not influence the physical and mechanical properties of the mixed cement significantly. The hydration rate and results of mixed zeolite cement have been considered for times of up to 360 days in this work. Thermoanalytical techniques (TG/DTG and DTA) have been utilized to survey the hydration rate of the mixed cement. To recognize hydrated items, X-ray diffraction and FTIR spectroscopy were utilized. As finished up, the fuse of zeolite into cement adds to the utilization of $Ca(OH)_2$ framed amid the hydration of cement and the development of hydrated cement like items. The pozzolanic response of the zeolite is somewhat moderate amid the primary long periods of hydration, yet it is quickened after the 28 days as detailed by Kontori [18].

Canpolat [19]stated in this examination, the impacts of zeolite, coal base ash and flew ash as Portland cement substitution materials on the properties of cement are explored through three distinct blends of tests. These materials are substituted for Portland cement in various extents and are resolved for physical properties, for example, time setting, volume development, compressive strength and water consistency of the mortar. These physical attributes are then contrasted with PC 42.5. The outcomes demonstrated that substitutes particularly affect the mechanical properties of the cement. The consideration of zeolite at 15% prompted an expansion in compressive quality in early ages yet prompted a decrease in compressive strength when utilized in mix with fly ash. The setting time was additionally decreased when zeolite was supplanted. Contrasted with Turkish principles (TS), the outcomes acquired were observed to be over the base prerequisites.

Andrejkovičová [20] detailed in this work inspects the impact of clinoptilolite, a characteristic zeolite, as a filler on the mechanical execution and the adsorption capacity of metakaolin-based geopolymers of substantial metals. In the combination of four diverse geopolymers (MK100, MK75, MK50, and MK25), clinoptilolite has been picked as a low - cost added substance with a high adsorption limit, supplanting metakaolin (0, 25, 50 and 75%). To create geopolymers with low ecological effect, the $SiO_2/Al_2O_3$ and $Na_2O/Al_2O_3$ molar proportions were kept steady at one amid the polymerization procedures to limit sodium silicate and sodium hydroxide. The last items were examined with X-ray diffraction powder, NMR 27Al and 29Si strong state and microscopy of electron checking. Additionally, strength and heavy metal parameters $Pb^{2+}$, $Zn^{2+}$, $Cu^{2+}$, $Cd^{2+}$, and $Cr^{3+}$ adsorption tests have been done. The outcomes demonstrate that geopolymerization within the sight of zeolite prompts an expansion in the compressive strength of all mixed geopolymers with an ideal precursor /zeolite filler ratio of 50:50( 8.8 MPa for 28 days). Metal cation adsorption on geopolymers was all around outfitted with a Langmuir display ($0.97 < R2 < 0.99$). The geopolymers adsorbed $Pb^{2+}>Cd^{2+}>Zn^{2+}$, $Cu^{2+}>Cr^{3+}$ overwhelming metals. The most extreme adsorption limit of

Cu2+ and Cr3+ was the most noteworthy for 100 percent metakaolin (MK100) geopolymers, while the most astounding adsorption capacity with regards to $Pb^{2+}$, $Cd^{2+}$ and $Zn^{2+}$ was for 75 percent metakaolin (MK75) geopolymers, demonstrating that 25 percent zeolite expansion to geopolymers enhanced the adsorption limit effectively.

### 1.2. Concrete containing synthetical or natural zeolite

Girskas [21] revealed the impact of manufactured zeolite on properties of concrete mix and hardened concrete. Zeolite was acquired by low - temperature union from the waste of aluminum fluoride creation and included concrete mixtures up to 10 percent as Portland cement supplanting admixture. The test outcomes demonstrated that the substitution of cement with engineered zeolite altogether lessens the scaling of cement amid solidifying and defrosting cycles. The test outcomes demonstrated that engineered zeolite acquired by low-temperature synthesis from aluminum fluoride could be utilized as an extra cement material to build the durability of concrete.

Monzón [22] revealed the strong advanced with NaA zeolite was synthesized from a coal fly ash, and the so-got zeolitized material was utilized as particle trade for purging fluid arrangement containing cadmium cations. Mechanical strengths and drying shrinkage estimated on cement mortars containing close to ten wt percent of the zeolitized item demonstrated that the cement properties stayed unaltered, like those of mortars in which non-zeolitized starting fly ash was used in the formulation of the mortar. SEM investigates of broke mortars demonstrate that the zeolitized fly ash particles are firmly anchored are concretely moored inside the microstructure and that the molecule surfaces are thickly secured with hydration items. To examine the practicality of the last transfer of the cadmium sludge got after particle trade, a draining test was done on cement pastes containing ten wt percent cadmium traded zeolite (Compact disc ZFA10) demonstrating that the present strategy is a compelling technique for the immobilization of the substantial metal.

Emam [23] expressed the pozzolans and valuable cementitious materials (SCM), either common or artificial, are regularly utilized as an enhancer material supplanting for cement with different percentages in concrete. Proficient option and creative green materials ought to be utilized for cost reasons. Silicon dioxide in zeolite will build the compressive strength of concrete by responding with the calcium hydroxide amid the cement hydration process. This examination gives a comprehensive laboratory study of the effects of zeolite (untreated and calcinated) as a pozzolan on the properties of fresh and hardened concrete and on the durability of concrete (e.g. ingestion and high temperatures) at various dimensions of Portland cement substitutions (from 0 to 40 percent by load of concrete materials). Fresh concrete properties (e.g., usefulness and unit weight) were clearly influenced by the consolidation of zeolite, but the primary impact was a noteworthy decrease in functionality, particularly at levels higher than 10 percent, which requires the expansion of medium - range and high-range water to diminish the admixtures in concrete mixtures, and furthermore an observable decrease in the unit load of concrete Contrasted with the control mixture, zeolite-mixed concrete mixtures (untreated and calcined) demonstrated an enhancement in compressive strength at 10 percent cement substitution level (7, 28 and 56 days), while 25 to 40 percent substitutions brought about a humble decline in strength at a similar age. In late ages, pozzolanic activity enhances strength more than in early ages. The zeolite pozzolanic activity improved the compressive strength of concrete.

A detailed investigation of the designing properties of concrete containing natural zeolite as an extra cement material is exhibited in the blended Portland cement binder with a mass substance of up to 60 percent. The parameters examined incorporate basic physical, mechanical and fracture-mechanical properties, durability and thermal properties and hygric. Exploratory outcomes demonstrate that the best choice is 20 percent zeolite content in the blended binder. flexural strength, effective fracture toughness, Compressive strength, efficient toughness, and specific fracture energy are just somewhat more terrible for this cement trade level than for the Portland cement reference. Frost resistance salt de-icing resistance and HCl chemical resistance, and $MgCl_2$, $NH_4Cl$, $Na_2SO_4$ are improved. The hygrothermal execution of solidified blends containing 20% natural zeolite, as estimated by the deliberate water absorption coefficient, water vapor dispersion coefficient, water vapor sorption isotherms, thermal conductivity, and explicit heat capacity, is satisfactory.

Natural zeolite is a functioning pozzolan material which is utilized as an extra cement material to enhance the last properties of concrete. The thermal properties of hardened high - performance concrete containing common zeolite in the measure of 0 to 60 percent of the cement binder are researched in this paper. The hydration and pozzolanic response in the concrete is explored by differential examining calorimetry and thermogravimetry relying upon the measure of natural zeolite included. The examination is completed in an argon atmosphere in a temperature scope of 25 to 1000 ° C at a rate of 5 ° C $min^{-1}$. We found that the temperature and enthalpy of the arrival of physically bound water, C–S–H gels and ettringite decay (all occurring between 50 and 300 ° C) scarcely change with the measure of natural zeolite in the samples examined. For portlandite (420–510 ° C) and calcite disintegration (580– 800 ° C), then again, they decline with common zeolite content. At long last, the last temperature alteration at 857 ° C was credited to the crystallization of quernstone, as composed by Trník [24].

AzariJafari [25]stated the impacts of three superplasticizers, to be specific, poly-carboxylate ether, calcium lignosulfonate, and Naphthalene Sulfonate Formaldehyde, on the functionality maintenance of NZ mixed mortars were explored. Additionally, the concurrent consideration of either tripolyphosphate retardant or $Na_2SO_4$ admixtures was explored as a measure to relieve the loss of usefulness of NZ blended mortars. The similarity of zeolite cement with three distinctive superplasticizers was additionally considered via doing adsorption isotherm tests, zeta-potential tests and pH estimations of pastes at various occasions. Results demonstrated that the decrease in the measure of electrostatic charge (which happens by NZ incorporation) is a compelling parameter adding to the higher usefulness misfortune for lignosulfonate and naphthalene sulfonate superplasticizers. Then again, the outcomes demonstrated that the essentially high polymer adsorption was the principle purpose behind the watched functionality loss of NZ blended mortars for polycarboxylate ether admixture.

In Portland cement composites, the examination inspected the likelihood of effectively solidifying and stabilizing waste zeolite saturated with overwhelming metal particles. The natural zeolite utilized in the expulsion of substantial metal ions from waste water in the zinc-covering industry must be for all time dealt with in a way that isn't destructive to the environment. Microcalorimetrically estimations were completed to decide the impact of the 0-50 mass percent waste zeolite content on hydration forms in CEM I Portland cement type. A standard filtering test, USEPA TCLP, was utilized to test the success of solidification and stabilization.

In its liquid synergist breaking units, the petrochemical business utilizes zeolites as impetuses. The fluid breaking impetus (SFCC) is utilized after a few cycles of utilization and recovery. Because of its substance piece (aluminosilicates), SFCC can be utilized as blends in the generation of mortar and cement. The target of this examination was to research the effect of SFCC on the toughness related properties of cement, specifically air penetrability, hairlike suction, carbonation and chloride opposition, considering its synchronous use with consumption inhibitors. A test program involving four cement blends, inspected in two bunches, was produced. The water flexural proportion (concrete + SFCC) and the measurement of the plasticizer were kept up reliably. Factual investigation of results has been completed. Despite the fact that there was no synergistic impact of the consolidated utilization of SFCC and consumption inhibitor, SFCC was a fascinating extra cement solidifying material about its sturdiness and the related positive ecological effects as announced by Neves [27].

Text style [28] detailed This investigation displays a new cellular concrete structure with an attention on vitality effectiveness and the idea of supportability: eco-cellular geopolymer (GECC). Made of alkali-activated fluid cracking catalyst residue (FCC) ) aerated by reused aluminum thwart powders (R) geopolymer frameworks have been structured. Commercial aluminum powder (A) was additionally utilized in the GECC matrix as a aerating agent, and its impact was contrasted with conventional cell concrete (TCC) produced using customary Portland cement (OPC). The more alkaline the GECC framework medium enhanced the hydrogen response rate, and in this manner a higher proficiency in the advancement of the pore grid can be found. The expansion of 0.2 percent of aluminum powder by weight of the antecedent (FCC) was adequate to deliver cellular concrete with a natural density much lower than that found for TCC. The substitution of A by R empowered the generation of an option GECC in which the reusing of aluminum squander assumes a vital job in natural effectiveness because of its ease and vitality sparing capacities. Ground R has less proficiency in air circulation than A. Nonetheless; on account of the co-milling of FCC + R, worthwhile GECC execution was accomplished. This material has gotten energizing properties: proper matrix distribution and good pore size, low natural density (600– 700 kg/m$^3$), moderately high compressive strength (2.5– 3.5 MPa), low open/shut porosity ratio (1.15) and lowest thermal conductivity (0.581 W/mK). This opens up a fascinating method to reuse both FCC as a precursor and aluminum foil waste as a circulating air through operator in the advancement of newheco-cell geopolymer concrete (GECC).

Two types of waste are created in fluidized catalytic cracking refinery units: the harmony impetus, which is persistently expelled from the catalytic regenerator, and the catalyst fines (Epcat), which are hauled by the gas stream leaving the regenerator and isolated by typhoons or electrostatic precipitators. This examination plans to contemplate the early hydration phases of Type II Portland cement, mostly supplanted by Epcat. For this reason, pastes were set up with a water/(cementitious material) ratio (W/C) of 0.5 and substitution degrees up to 30 percent mass of cement per Epcat, which were analyzed by non - customary thermal differential examination amid the initial 24 hours of hydration. The deconvolution of the NCDTA bends acquired amid the beginning times of cement hydration demonstrates that ettringite and tobermorite have an invert relationship development in the beginning periods of hydration, contingent upon the degree of substitution, which demonstrates a directly developing ettringite content, as the tobermorite content decreases. The energy collected from the NCDTA bend information demonstrates that Epact has pozzolanic activity, which increases with the degree of substitution, likewise appeared from the individual bend deconvolution information as revealed by Lemos [29].

A heterogeneous catalyst, ZnO/spent fluid catalytic cracking catalyst (ZnO/$FC_3R$), was integrated utilizing a sol-gel strategy and utilized for rosin and glycerol esterification. The catalyst was characterized by X-ray diffraction, Fourier changes infrared spectroscopy, Brunauer– Emmett–Teller surface territory and filtering electron microscopy- energy dispersive spectroscopy, and the outcomes demonstrate that $FC_3R$, which is viewed as a waste block, is a perfect substrate because of its aluminosilicate structure. The upheld ZnO is effectively stacked onto the $FC_3R$ surface offering ascend to extra Lewis corrosive locales with a funnel shaped structure of 47 nm on average. The consequences of pyridine adsorption IR have demonstrated that ZnO/$FC_3R$ has both Lewis and Bronsted acids. The ideal conditions for rosin and glycerol esterification incorporate a response temperature of 270 ° C, a response time of 2.5 hours, a molar ratio of 2:1 rosin/glycerol and a weight ratio of 1.6 percent catalyst/rosin. In ideal reaction conditions, the change of rosin was 96.13%. The ZnO/$FC_3R$ stayed effective after five runs, and the transformation was 94.76 percent. ZnO/$FC_3R$ exhibited high action and good soundness, showing potential use as a heterogeneous catalyst for the esterification of rosin and glycerol as composed by Wang [30].

Waste water delivered from the cleaning of the concrete truck drum in ready-mixed concrete plants has as of late been restricted from direct transfer into ground or surface water. Later environmental controls require ready-mixed concrete plants to utilize a reusing framework to contain and manage waste water until the point when it is ecologically satisfactory for release. This examination meant to research water quality standards in Florida and the likelihood of reuse of concrete waste water as total water system as well as group blending water for crisp concrete generation. The outcomes demonstrate that the waste water utilized in this examination, which did not meet the water quality details of the Florida Division of Transportation (FDOT) however agreed to water quality standards, had no unfriendly impacts on genuine properties. In view of information from this task, it is prescribed that the FDOT water quality particular is enhanced to address the utilization of waste water as total water system as well as group mixing water for fresh concrete generation as detailed by Chini [31].

Rahhal [32] expressed in This paper examines the expansion of natural zeolite (NZ, 84 percent clinoptilolite) (0-40 percent w/w) in mixed cement made with low and medium $C_3A$ substance of Portland cement (PC). The isothermal calorimetry was utilized to comprehend NZ's impact on the early hydration of cement. In low $C_3A$ concrete, the expansion of NZ basically delivers a weakening impact, and the heat-released curve is like low- intensity cement. For standard $C_3A$ cement, the bend shows the $C_3S$ crest ahead of time and a high third pinnacle force because of the hydration of $C_3A$. The high NZ cation decreases the convergence of ions (particularly soluble bases) in the blending water that invigorates the hydration of the PC. The stream rate diminishes as the dimension of NZ substitution increase. Fratini 's test results demonstrate that NZ has a moderate pozzolanic movement with the two PCs. At an early age, XRD and FTIR break down affirm that hydration items are equivalent to the comparing PC and that CH is bit by bit diminished following 28 days and some AFM stages (hemi-and monocarboaluminate) happen contingent upon the level of NZ and the PC utilized. For low dimensions of substitution, the compressive strength is higher from 2 to 28 days than the relating PC. The early compressive strength is lower than that of the comparing plain PC for high substitution levels, and the pozzolanic reaction improves the later compressive strength of mixed cement. The concrete mixture utilized for testing was CEM I 42.5 R cement, natural zeolite (clinoptilolite), 0/4 fr. Fine aggregate sand and 4/16 fr. Gravel as a total obviously. Dynamic segments of zeolite were controlled by SEM utilizing X-ray diffraction analysis, molecule shape (plate-molded) and estimate (11.82 μm). Five loads of samples were created with a zeolite substance of 0 to 10 percent (flexural material was supplanted by natural zeolite).

The accompanying parameters of adjusted concrete were tried: compressive strength, retention of water, density, the velocity of the ultrasonic pulse, porosity (open and shut), predicted resistance to freezing. Substitution with natural zeolite of up to 10% cement builds the compressive strength of concrete by 15%, decreases water absorption by multiple times, expands density and ultrasonic heartbeat speed. Substitution with natural zeolite of up to 10 percent cement expands the shut porosity and subsequently improves the freezing resistance of concrete. The forecast freezing opposition figurings indicated 3.3 occasions higher obstruction of adjusted concrete with up to 10% natural zeolite as composed by Nagrockiene [33].

Milán [34] expressed the In group minidigesters of 50 mL at centralizations of 0.01, 0.05 and 0.1 g zeolite/g of VSS, catalytic or inhibitory impacts of the expansion of modified and natural zeolite to anaerobic assimilation of piggery waste were examined. The impact of the various zeolite focuses was controlled by the aftereffects of the sludge 's potential methanogenic action. Dynamic portrayal of the gathered volume of methane gas has additionally been performed. The impact of natural and nickel zeolite focuses in clump digesters of 2,5 L in the second period of the investigation was tried by expanding the natural load from 0,2 to 22,0 g COD. An increasingly noteworthy impact of modified natural zeolite has been seen on sludge activity, with an expansion of 8.5 times magnetic zeolite, 4.4 times cobalt zeolite and 2.8 times nickel zeolite. In the active investigation, two stages were characterized, and an expansion in the obvious consistent of digesters with modified zeolite was seen in the second stage by multiple occasions. Modified natural zeolite expansion to digesters can build the potential biodegradability of the strong portion of piggery waste as well as altogether lessen the volume of assimilation.

## 1.3. Cement systems with sludge from ready-mixed concrete

Chatveera [35] detailed notwithstanding the expanded expense of transfer, sludge water, a waste water washout from ready-mixed concrete plants, has made environmental problems. This paper looks at the utilization and reusing of sludge water as a water blending for the creation of concrete. The crucial properties of sludge water. The properties of dry sludge powder have been examined, for example, compositions physical properties and chemical. Unit weight, slump, and temperature rise were the properties of fresh concrete considered. The mechanical properties of the concrete, for example, elasticity modules and compressive strength, have been researched. The durability aspects have been explored, for example, drying shrinkage and weight reduction because of corrosive assault. Sludge water was utilized as a swap for faucet water of 0 % to 100 % by load for parametric examinations. The proportions of water to cement were individually 0.5, 0.6 and 0.7. The sludge water tried in this investigation has high alkalinity, adding to an increasingly permeable and flimsier network. Accordingly, the drying shrinkage and weight reduction because of corrosive assaults expanded when the level of sludge water in blending water expanded and the strength decreased and slump. In any case, sludge water was not influenced by the unit weight and temperature of fresh concrete.

The transfer of extra concrete and wash water from ready-mixed concrete trucks are progressively a worry for the environment. The main concern is the amount of waste water delivered by the cleaning of these trucks. The second concern is the impact, assuming any, of these materials, which the EPA considers to be perilous when surface water and groundwater are tainted. This exploration venture examined the reusing capability of these waste materials for mortar and fresh concrete creation as a reusing help, a generally fresh settling blend has additionally been researched. The subsequent mortar was tested for compressive strength, protection from sulfate, operability and time setting as revealed by Borger [36].

Su[37] demonstrated that the investigation manages the impact of different kinds of water blending on a mortar and concrete properties, for example, setting times, compressive strength and workability. Tap water, underground water and wash water from blender washing activities in a ready - mixed concrete plant are utilized for mortar and concrete. This investigation evaluates the nature of these water types. Tests were then done on mortar and concrete. All underground water and wash water tested to blending water necessities for ready - mixed concrete. Concrete mixed with base wash water gave a shorter setting time, and a lower stream rate since some lingering cement is in the base wash water. The lump of fresh mortar was not altogether influenced by middle and top wash waters or by underground water. The compressive strength of concrete mixed with wash water or submerged is on a par with the compressive strength of tap water. It is in this manner recommended that underground water ought to be reused as mixing water for concrete and wash water where tap water is rare. It is, be that as it may, prudent to think about different properties, for example, shrinkage or durability.

Sandrolini[38] revealed that the production of large amounts amounts of waste water from ready-mixed concrete plants results in environmental impact problems. Because of their to a great degree high pH quantity and the value of suspended issue, national laws for the most part preclude the transfer of these sorts of water and require treatment of the water before release. The utilization of waste water (from a medium - sized ready - mixed concrete plant) in concrete and mortar mixing water was explored in this paper: the consequences for physical-mechanical properties and microstructure are researched as an element of the attributes of the waste water utilized. The outcomes demonstrated that concrete and mortar created with reused water not the slightest bit show a mechanical strength of 28 days beneath 96 % of the reference materials in some cases, even better. Moreover, the utilization of wash water in concrete prompts a decrease in the absorption of concrete capillary water and the mortar micro porosity, which unquestionably enhances the material's durability.

Sogancioglu [39] expressed the travertine sludge treatment is a by-product of travertine marble preparing plants. These treatment sludges are delivered in substantial amounts of marble creation offices in Turkey. Distinctive extents (5– 15 percent w/w cement) of physicochemical sludge admixtures acquired from the physicochemical treatment (coagulation-flocculation) of the travertine squander water treatment plant were utilized to supplant concrete with 250 kg/m$^3$ of cement. Slump tests on fresh concrete were done and compressive strengths for 7 and 28 days of hardened concrete samples were resolved. Freeze / take opposition, water absorption, capillary suction, vacuum porosity and ratio of the hardened concrete samples were done. Considering the properties of hardened concrete, for example, workability, compressive strength, and physical properties, AS and NS are the blends that can be recommended both to enhance the concrete properties and to make another waste material use zone. Higher 28-day compressive strength of around 28.43 MPa (AS) and 28.82 MPa (NS) was accomplished by load of cement at 15 % admixing level, while the compressive strength of the reference test was 25 MPa.

Audo[40] detailed in the investigation that sludge from ready-mixed concrete plants was fused into mortars. Fundamental environmental investigations brought out through filtering tests indicated that it is so imperative to deal with these waste, as it tends to be conceivably contaminating concerning its arsenic and chromium content. Sludge the executives would thus be able to be earth and financially difficult. It is quite compelling to reintegrate these sludges into a shut circle concrete generation. It is additionally a fascinating method for sparing initial materials (fillers of water, sand and calcareous). In any case, two primary burdens were seen when these sludges were utilized as a substitute for calcareous fillers:

- A decrease in the workability of the fresh state mortar, which requires a higher superplasticizer content;
- Variability in the compressive strength of the hardened state mortars, between −30 % and + 17 percent when contrasted with a reference mortar.

## 1.4. Task

- What is the values of density and compressive strength and flexural strength of hardened cement paste with sludge or with sludge and zeolitic waste?
- How much effected sludge and zeolitic waste on the mechanical and physical properties of concrete?
- How acted the supplementary cementing materials (sludge and zeolitic waste) on the frost resistance of concrete specimens?

## 2. Experiment methods and materials

The point of the examination is to research the effect of sludge blends on innovative parameters and the porosity of fresh or hardened sludge-modified concretes. Utilizing a few explanatory procedures, they were concentrated to portray and look at tests of changed sludge rates and to decide their utilization esteem in explicit frameworks.

### 2.1. The used experimentation methods

To achieve the objectives of this work we did the following tests:

#### 2.1.1. X-ray powder diffraction (XRD)

X-ray diffractometer DRON-6 was used for the X-ray diffraction analysis with the help of CuKα radiation and Ni filter. The powder X-ray diffraction patterns were identified with references available in the PDF-2 database (PDF – 2 International Centre for Diffraction Data, 12 Campus Boulevard Newtown Square, PA 19073-3273 USA).

#### 2.1.2. X-ray fluorescence (XRF)

X-ray fluorescence (XRF) was conducted for elemental and chemical analysis of the dry sludge from waste water concrete plants and zeolitic waste. Loss on ignition, was calculated after heating materials at the temperature of 1000°C. Particle size distribution and specific surface area were determined by “Mastersizer 2000” instrument from Malvern. Red light was produced by helium-neon laser and blue light was obtained from a concrete phase source. The measuring principle was used Mie scattering analysis.  The compressive strength of hardened cement pastes specimens was evaluated after seven and twenty-eight days according to EN 196-1. The press Toni Technik 2020 was used to compress the sample cubes. The density of samples was determined according to EN 12390-7.

#### 2.1.3. Determine water absorption

In concrete quality, sludge and zeolite quality assume a noteworthy job. This mirrors the geometrical, physical and compound attributes of concrete samples (with sludge and zeolite). Water is fundamental for the hydration of cement, which gives concrete its mechanical strength, however it must be sufficiently dosed. A lot of water builds the porosity of the concrete and decreases mechanical execution and durability. The absence of water in the blend prompts deficient responses in cement hydration and decreases the functionality of fresh concrete.

### 2.1.4. Determine flexural test

The main aim of this study is to determine the difference in bending capacity(Figure 1) between a single reinforced monolithic beam and a single reinforced beam with a construction joint in the beam center for a variety of compressive strengths (f'c) of concrete. Typical applications are concrete, masonry and shotcrete.

Figure 1: flexural concrete specimens test

### 2.1.5. The compressive strength of hardened cement paste samples

Compressive strength is one of the most important mechanical properties of concrete thus this test can greatly help to define the cons and pros of the addition of the sludge to the cement paste (Figure 2); The water/concrete material ratio was 0,35.

Figure 2: Compressive strength test of the hardened cement paste specimens

The press Toni Technik 2020 was used to compress the sample cubes. The density of the samples was determined according to EN 12390-7.

The experiment has been carried out according to the schemes which was shown in figures 3 and 4.

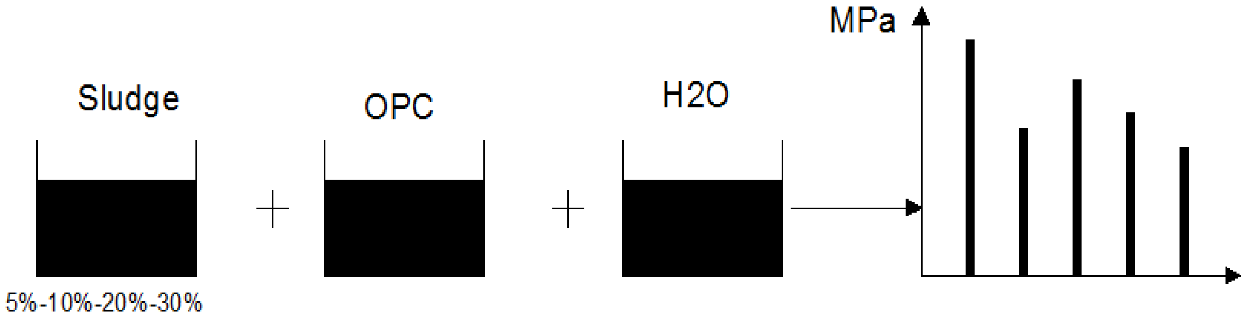

Figure 3: sludge Diagram of mixing cement paste without Zeolitic waste after 7and 28 days

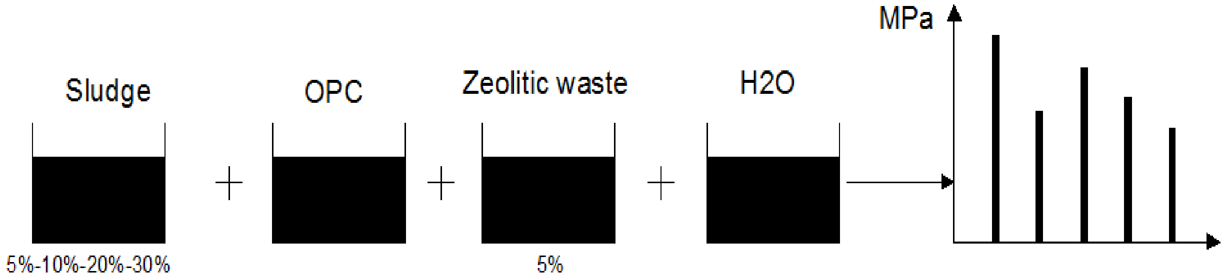

Figure 4: Diagram of mixing cement paste with Zeolitic waste after 7 and 28 days

## 2.2. Initial materials

### 2.2.1. Portland cement powder

As flexural material, the commercial Portland cement type CEM I 52.5R was used for the tests (mineral composition $C_3S$ = 50.7 %; $C_2S$ = 18.5 %; $C_4AF$ = 14.2 %; $C_3A$ = 9.7 %). Table 1 represents the oxide composition of the Portland cement clicker. It was found that CaO and $SiO_2$ have the highest amount in the oxide clinker composition.

There are many different kinds of cement. In concrete, the most commonly used is Portland cement, a hydraulic cement which sets and hardens by chemical reaction with water and is capable of doing so under water. Cement is the “glue” that binds the concrete ingredients together and is instrumental in the strength of the composite.

As valuable cementitious materials dry sludge and zeolitic waste was used. The sludge from waste water (suspension) concrete plants is ready-mixed concrete truck contains returned plastic concrete.

This material normally washed out with the addition of water. This water (suspension) is collected in sedimentation bowls and in some Lithuanian designs don't reuse. After some time, the suspension layered: solid part goes down. In this examination the strong part use as cement supplementary material. Hence, sludge was isolated from water and after that it dried in oven at 100 $^{o}$C.

CEM I 52.5R Portland Cement is a hydraulic binder. The main component is Portland cement clinker, finely ground together with calcium sulphate, which controls the setting time for CEM I 52.5R. Stringent production control during the entire production process ensures consistent high quality. CEM I 52.5R Portland Cement can be used in applications where a higher early strength class is required. It can be used in ready-mix concrete, precast concrete or production of concrete goods.

- Typical applications are concrete, masonry production, and shotcrete.
- Higher earlier strength in counteracting the effects of cold weather conditions
- Gives higher early strength for a given cement content
- Earlier pre-stressing for pre-stressed concrete
- Earlier stripping time for molds and formwork
- CEM I 52.5R is compatible with commercial chemical admixtures.

Earlier strength to counteract the effects of cold weather—Earlier pre-stressing or pre-stressing of concrete — Earlier stripping time for molds and forms— CEM I 52.5R is compatible with commercial chemical admixes. The commercial Portland cement type CEM I 52.5R was used for testing. Table 1) is the oxide composition of the cement paste, where the highest ratio of CaO and $SiO_2$ is found. These oxides interact with each other at high temperatures in the oven to create more complex compounds. The relative proportion of these oxide compositions influences the various characteristics of the cement, as well as the cooling rate and fineness of the process. Table 1 shows the approximate oxide composition limits for ordinary Portland cement.

### 2.2.2. Zeolitic waste

Zeolite was obtained from oil industry plants by low - temperature synthesis and added to the concrete mix as a Portland cement substitute for a mixture of up to 10%. The test results showed that cement substitution with synthetic zeolite reduces the scaling of concrete during freezing and thawing cycles significantly. The strength of compression, concrete density and water absorption were measured. The test results showed that synthetic zeolite obtained from low - temperature synthesis aluminum fluoride could be used as a complementary cement material to improve the durability of concrete[21]. It was obtained from the public company ORLEN Lietuva. The element composition as shown in (Table 1).

### 2.2.3. Dry sludge from waste water concrete plants

Dry sludge and zeolite waste have been used as additional materials for cement. This material was usually washed out with water. This water is collected in sedimentation basins and is not used again in certain plans in Lithuania. The ready - mixed concrete truck includes the returned plastic material. This material was usually washed out with water. This water is collected in sedimentation basins and is no longer used in certain plans in Lithuania.

Table 1 shows the approximate oxide composition limits for ordinary Portland cement.

Table 1: Oxide composition of the clinker, sludge and zeolitic waste %

| | **Portland cement CEM I 52.5R** | **Sludge** | **Zeolitic waste** |
|---|---|---|---|
| $Al2O_3$ | 3.90 | 3.2 | 53.1 |
| MgO | 2.70 | 2.9 | 0.474 |
| $SO_3$ | 3.40 | 2.06 | 0.192 |
| $SiO_2$ | 21.00 | 19.7 | 37.1 |
| $Fe_2O_3$ | 2.90 | 2.25 | 0.585 |
| CaO | 66.00 | 35.8 | 0.056 |
| Cl | 0.06 | 0.077 | - |
| SrO | - | 0.035 | - |
| $TiO_2$ | - | 0.22 | 1.03 |
| $K_2O$ | - | 0.72 | - |
| $P_2O_5$ | - | 0.46 | 0.084 |
| $La_2O_3$ | - | - | 1.63 |
| MnO | - | 0.052 | - |
| $Na_2O$ | - | - | 0.312 |
| L. I : the loss on ignition | - | 51.8 | 5.44 |
| Bulk density, $g/m^3$ | 1.236 | 0.668 | 0.864 |

### 2.2.4. Aggregates

Aggregate materials used that are usually chemically inactive. And because they are cheaper than cement, they are mixed with it and dispersed throughout the cement matrix mainly to reduce the cost of the concrete. Raw materials used for preparing mortar and concrete mixtures. These materials are fine aggregate, coarse aggregate, and Cement.

Figure 5: Course aggregate using in concrete mixing

General using two sizes of aggregates in concrete mixtures: coarse aggregates and fine aggregate, and one type using in the preparation of mortar.

### 2.2.5. Supper plasticizer name and company

Superplasticizer is a condition of the exploration of materials in which solid crystalline material is disfigured well past its standard breakpoint, normally over 200% during tensile deformation. Such a condition regularly happens at high temperatures. Examples of superplastic materials are some ceramic and fine-grained metals. Other non-crystalline (amorphous) materials, for example, silica glass and polymers, also deform, but are not referred to as superplastic because they are not crystalline. Super plasticizer distorted material is extremely more slender than a " neck " that outcomes in crack as composing by Sharma, G. [41]

### 2.2.6. The mineral composition and particle size distributions

The mineral composition of sludge was evaluated by XRD analysis. It showed peaks of quartz and calcite. There was small amount of dolomite and anorthoclase (Figure 6). According to XRF analysis the highest amount of oxide consisted CaO and $SiO_2$.

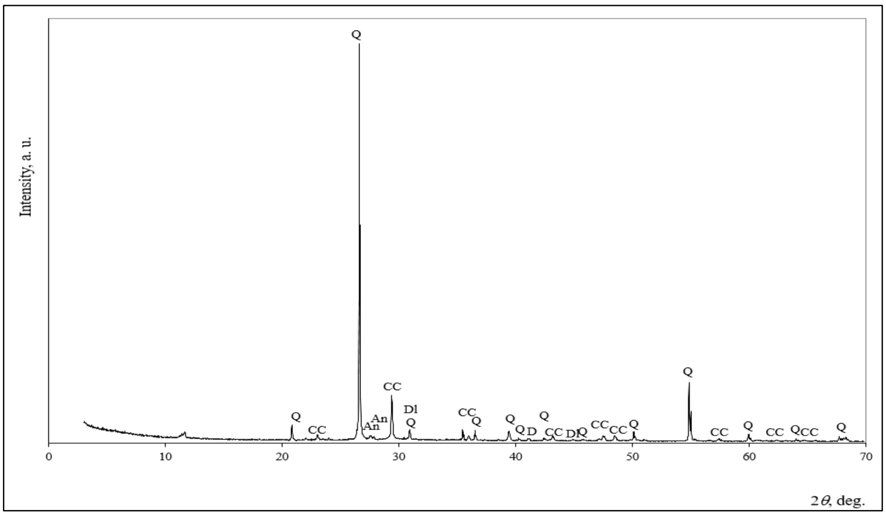

Figure 6: X-Ray diffraction pattern of dry sludge

Notes: Q–quartz $SiO_2$ (78–1252), CC – calcite $CaCO_3$ (81–2027), Dl – dolomite $CaMg(CO_3)_2$ (84–1208), An – anorthoclase Na0.71K0.29AlSi3O8 (10–361).

In the catalytic fluid cracking process, zeolites are commonly used. Zeolites became waste after some time. The quantity of these waste inevitably increases as the oil industry expands rapidly. Zeolitic waste local oil company was used. The oxide composition was shown in (Table 1). In this material, silicon and aluminum oxides predominated.

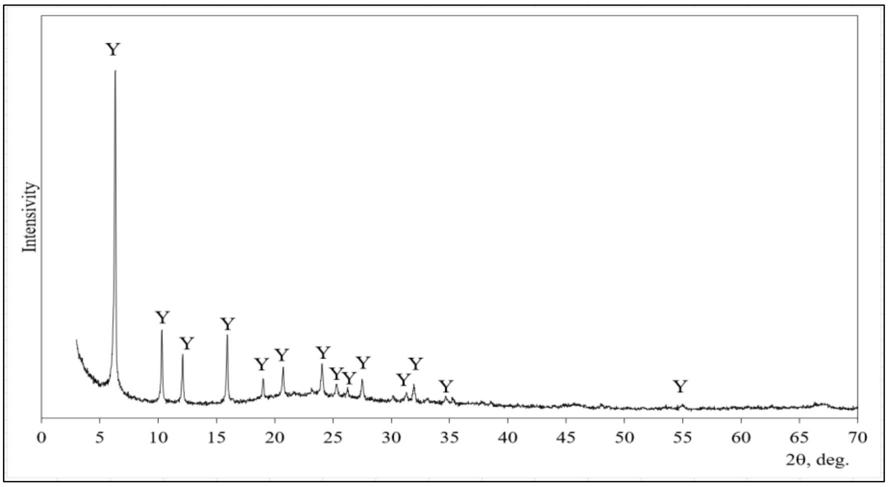

Figure 7: X-Ray diffraction pattern of zeolitic waste

Notes: Y is zeolite Al60.352·Si139·O371.52·H5.984 (73-2313).

According to XRD analysis zeolitic waste mainly contain zeolite Al60.352·Si139·O371.52·H5.984. with the specific diffraction peaks (d is 1.399; 0.857; 0.731; 0.556; 0.429 and 0.370 nm), are characteristic of zeolite Y (Fig. 7).

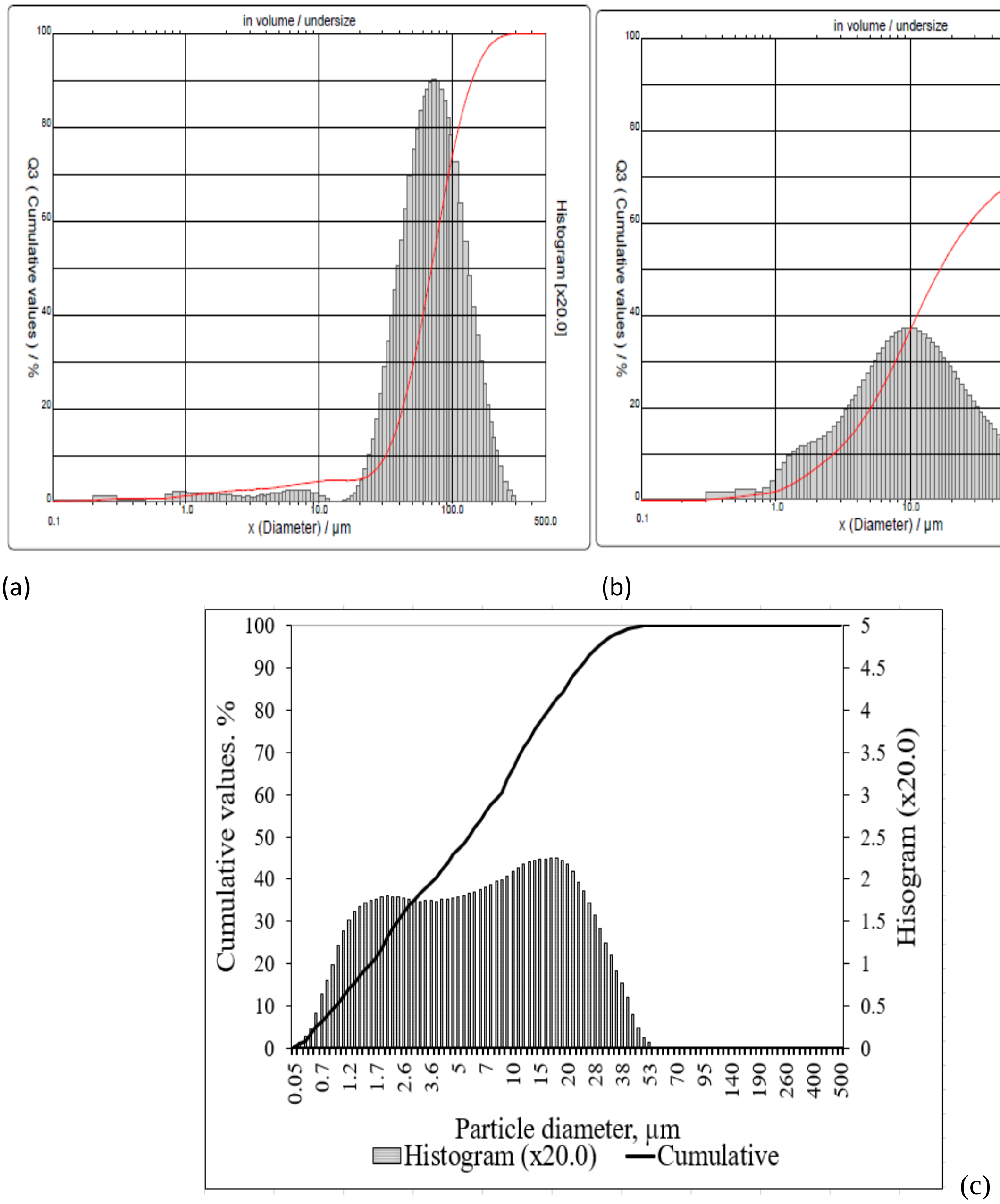

Figure 8 : Particle size distributions of zeolitic by-product (a), Portland cement (b) and sludge (c)

The composition curves of cement and zeolite are shown in the granulometric composition (figure 8 a). The results of the granulometric analysis showed that the particle distribution of zeolite wastes ranges from 31,46 mm to 140,04 mm in diameter, forming a peak of 78,39 mm with 10,25 % of all histogram particles with a specific particle surface area of 0,1403 $m^2/cm^3$. The distributions of the sludge particle size are displayed in the (Figure 8 b). The finest particles are 2,67 mm and 10 percent of all particles are coarser. Two peaks are EUR 90.84 and EUR 500. The particle's specific surface area is 0,1403 $m^2/cm^3$.

Meanwhile, the size of the Portland cement particles ranged from 0.05 ml to 52.5 ml, forming two peaks in the 1.8 ml distribution histogram (1.75% of all particles) and 19.42 ml (2.14% of all particles). The specific cement surface in Portland was 0,599. $m^2/cm^3$. So, Portland cement particles are almost four times finer than the particles of zeolitic waste.

### 2.3. Initial composition of the cement paste and concrete mixtures

In this work, there are 3 mixing, the first and second for cement paste (with and without zeolite).

The third one is for concrete samples.

#### 2.3.1. The initial mixtures of cement paste

Two sample arrangement were shaped. The ratio water/solid issue was 0.374. The first was a reference sample with no extra cement materials (Table 2, No R). The first series of samples were made of cement and dry sludge from Portland (Table 2, No 1 - 4). Four types of specimens were prepared later in the second series (Table 2, No 5 - 8). Mixtures of this arrangement series with ordinary Portland cement, zeolite waste and sludge have been readied. The total amount of SCM in composition of cement paste specimens does not surpass 35% of the coupling weight.

Table 2: Composition of the cement paste mixtures

| No | Portland cement (%) | Dry sludge (%) | Zeolitic waste (%) | Water H2O (%) |
|---|---|---|---|---|
| R | 100 | 0 | 0 | 37.4 |
| 1 | 95 | 5 | 0 | 37.4 |
| 2 | 90 | 10 | 0 | 37.4 |
| 3 | 80 | 20 | 0 | 37.4 |
| 4 | 70 | 30 | 0 | 37.4 |
| 5 | 90 | 5 | 5 | 37.4 |
| 6 | 85 | 10 | 5 | 37.4 |
| 7 | 75 | 20 | 5 | 37.4 |
| 8 | 65 | 30 | 5 | 37.4 |

The powder of Portland cement and dry sludge from waste water treatment plants with or without zeolitic waste mixed in dry condition until the mixture was homogeneous. Then water filled and the entire batch mixed until the cement paste appears to be homogeneous and has the desired consistency.

### 2.3.2. Concrete samples specimens:

In this study, there are 4 samples of concrete, the first one has a name is references, the percentage of sludge and zeolitic is 0%. The second sample has a name is one (1) the percentage of sludge 5% and zeolite 5%. The third sample has a name is two (2) the percentage of sludge 10 % and zeolitic 5%, and the fourth one has a name is third (3) the percentage of sludge 20 % and zeolite 5 %. According to the data have it, will mix the concrete samples.

**Last lab concrete:**

Cement = 350 Kg/m$^3$, Sand = 960 Kg/m$^3$, Aggregate = 950 Kg/m$^3$, Water = 143.5 L/m$^3$, Supper plasticizer = 3.5 Kg/m$^3$. We should mix 25 liters, so cement, sand, aggregate, sludge, zeolite and water multiply by 0.025.

**Bulk density:**

Cement : 1.445 – 0.209 =1.236, Zeolite : 1.073 – 0.209 = 0.864, Sludge : 0.877 – 0.209 = 0.668

Table 3:contains 4 mixings of concrete

| | **Cement Kg** | **Sludge Kg** | **Zeolite Kg** | **Sand Kg** | **Gravel Kg** | **Supper plasticizer g** | **Water L** |
|---|---|---|---|---|---|---|---|
| First reference: | 8.75 | 0 | 0 | 21.5 | 25.8 | 75 | 3.9375 |
| Second reference: | 7.875 | 0.4375 | 0.4375 | 21.5 | 25.8 | 75 | 3.9375 |
| Third reference: | 7.4375 | 0.875 | 0.4375 | 21.5 | 25.8 | 75 | 3.9375 |
| Fourth reference: | 6.5625 | 1.609 | 0.4375 | 21.5 | 25.8 | 75 | 3.9375 |

## 3. The methodology of specimens preparation

### 3.1. Cement paste

We start our work by placing the dry sludge in containers and add them in the oven at $48^0$C for 4 days. After 4 days we took them out of the oven and we crushed them to become very fine and ready for use (Fig. 9).

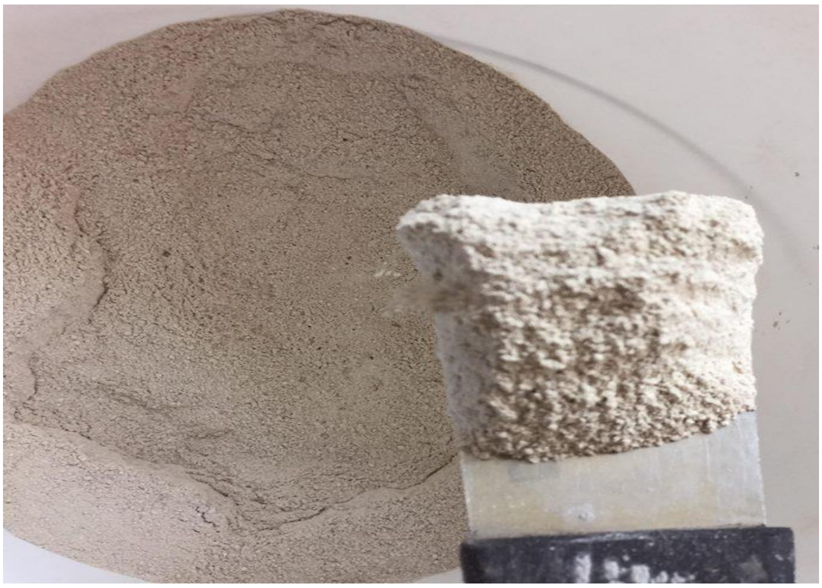

Figure 9: sludge powder

In our works we prepared 2 mixing of cement paste, the first one has Portland cement and sludge with water, and the second one has Portland cement and sludge and Zeolitic waste with water.

We start with cement paste, as this is the matrix material for the concrete composite and it is difficult to understand the composite's behavior without understanding the matrix phase first. Later, we will consider mortar and concrete, cement composites with higher length scales and individual cement paste phases such as C-S-H with lower length scales. The point of departure for cement paste= cement + water.

The cement and the sludge must be mixed dry until the mixture is completely mixed (Fig. 10). The water is then added and the entire batch mixed until the cement paste appears uniform and consistency is desired. The water is then added and the entire batch mixed until the cement paste appears uniform and consistency is desired.

If repeated mixing is required because the water is added in increments while the consistency is adjusted, the batch is discarded and a fresh batch is produced without interrupting the mix to test the consistency.

Figure 10: preparing the mixing

We start the mixing process with five mixtures of 6 cubes in the following quantities (Figure 11). Sludge specimens, Portland cement and waste were formed in the first place. The second type of paste was formed by the addition of 5% zeolite, sludge, cement and waste in Portland. When we balance these materials, we add them to the molds and stir until they are mixed very well. After specimens were hardened we check the mineral composition of them.

Figure 11: hardened cement paste specimens in the moulds

### 3.1.1. Place of Moulding

Mold specimens as near as practicable to the place where they are to be stored during the first 48 hours. Place molds on a rigid surface free from vibration and other disturbances. If it is not practicable to mold the specimens where they will be stored, move them to the place of storage immediately after being struck off.

### 3.1.2. Hydration process

After preparing the specimens we put them under water, then we wasted 7 days and 28 days.

### 3.1.3. Concrete samples

Concrete is a composite material consisting of a binding agent that is usually rough, cement and fine aggregates, usually sand and gravel, adding sludge, zeolite and plasticizer for suppers (Table 3). These comprise concrete components. However, there are many opportunities for specific problems due to the many variables of the raw materials and their processing and combination. In simple terms: mortar + stone = concrete.

**Proportioning of the concrete mix:**

- Basics of mix proportioning.
- Characteristics of concrete related.
- Physical properties of materials required for mix design.
- Styling mix and nominal mix.
- Mix design examples.

**Making cubes on site:**

Making and curing specimens for strength tests. They should be given a role as soon as the concrete is produced and sampled as close to its final storage position as could be allowed. If not accessible, the specimens ought to be remixed completely on a steel sampling plate or wrapped on a substantial plastic sheet or comparative impermeable material. The cube mold should be clean and slightly oiled. The mold ought to be lifted and dropped somewhat, or the sides to close the highest point of each layer ought to be taped. The final layer should slightly overfill the mold. At last, the top layer ought to be removed with the highest point of the form. All example and test gear ought to be cleaned following use. The fresh cube ought to be kept out of the boundaries of warmth and chilly. Preferably, they ought to be secured to anticipate surface dissipation and put away as close as conceivable to 20 $^{o}$C until the point that the molds are stripped and the cubes are put at the required temperature in the mending tank. On the off chance that the surrounding temperature is high, the concrete cubes can be placed in the mending tank in your molds. This ought to be done after the concrete is first reinforcement and care ought to be taken to avert surface unsettling influence or to wash out a portion of the examples as explaining by Anderson [42].

### Steps of Making concrete slumps

In this work, we prepared 24 cubes (10*10*10 cm) used for compressive strength and full absorption water, 8 cubes (10*10*25 cm) for flexural materials, and 8 cubs (15*15*15 cm).

### Preparation of the Molds

Set up the cylinder molds. Place all of them with the opening up on a flat, even surface. Keep all of your equipment easily accessible so that you can readily use it.

### Put the scoop into the mold

Rotate your hand clockwise as the concrete falls into the mold. Then fill the mold halfway. Rotating your hand as you put the concrete in the mold helps to create an even layer.

### Methods of consolidation

Preparation of satisfactory specimens requires different methods of consolidation . The methods of consolidation  are a) Rodding, b) Internal vibration, c) External vibration.

### Vibration

The duration of vibration required will depend upon the workability of the concrete and the effectiveness of the vibrator. Continue vibration only long enough to achieve proper consolidation of the concrete. Vibrate each model 30 times to be equivalent. Add the final layer. Then finish the surface.

### Finishing the specimens

- **Finish the surface:** Using the handheld float, carefully and slowly run it across the surface of the mold. As you keep doing this, it will create a smooth surface. It is helpful to get the float damp before doing this to help create a smooth surface.
- **Place a cap on the specimens:** Make sure they are on all the way to prevent moisture from escaping (Figure 12), and that they will not fall off during transport.

- **Add cylinder in water:** after 5 days should remove up that specimen from samples, than put in water for 28 days to do the tasting.

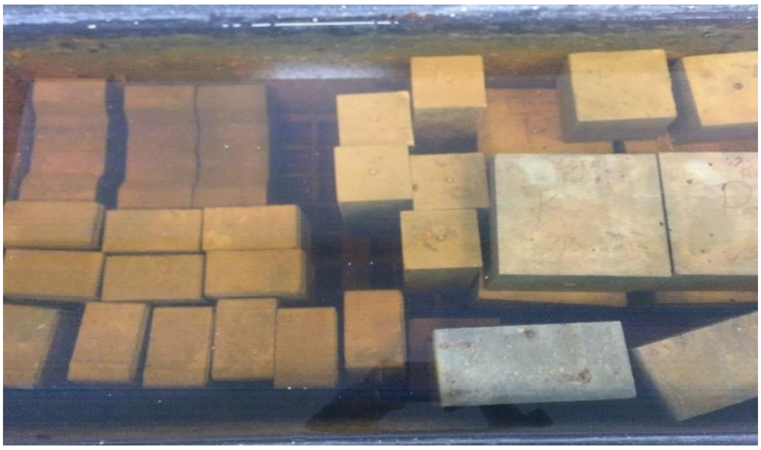

Figure 12: concrete cubs under water for 28 days

### 3.2. The determination of concrete specimens water absorption

An alternative method to determine the water absorption of samples is now presented. The hydrostatic scale test is used to determine the concrete samples' water absorption over time. The samples are placed in water has temperature 22 °C for 15 mints after that removed from the water and write the measure of each cube of concrete, than back all concrete cubs to water for 45 mints and take the mass, same way after than 24 hours . After putting the samples for 48 hours (3 days) in water should be removed that cubs from water and write the measure of each cube of concrete. Last work is taking the mass of samples but in water, in this case, should fall ap the tank as in (figure 14) and put hock from scale to water and measure the mass of all samples in water. Knowing this value it is then possible to determine the amount of water absorbed by the concrete between their immersion and the first reading on the scale.

### 3.3. Flexural test of concrete specimens

During humongous construction projects, it is very rare to build a concrete structure without instigating the use of construction joints, whether by design or by de facto forces. On site, the construction supervisor would contemplate whether one could relate the flexural capacity of the concrete beam with the use of accidently imposed construction joint (Figure 15).

Thus it is very essential to determine the effect the construction joint has on the flexural capacity of the concrete. Provided are charts to account for the loss in the flexural capacity of a singly reinforced beam in the existence of a construction joint for a specific concrete compressive strength.

## 4. Results and discussion

### 4.1. Hardened cement paste containing dry sludge from waste water concrete plants and zeolitic waste

In development ventures without the utilization of development joints, either by plan or by accepted powers, the development of a concrete structure is extremely uncommon. The building supervisor at the site would think about whether the bending capacity of the concrete beam could be connected to the development joint forced unintentionally. Along these lines, the effect of the development joint on the bending capacity of the concrete must be resolved.

The outlines gave mirror the loss of the flexural capacity of a singly reinforced beam within the sight of a basic joint for an explicit compressive quality of the solid. This work concerned the utilization of dry sludge from concrete wastewater plants to deliver hard cement paste.

The methods of research used were X-ray powder diffraction, electronic microscopy scanning, energy dispersive X-ray spectroscopy and thermal analysis.

The compressive strength of the hardened cement paste was measured on days 7 and 28. It was demonstrated that the addition of sludge reduced the compressive strength of the hardened cement paste for 7 and 28 days after the investigation. Compressive strength decreases significantly in the hardened cement paste specimen by replacing Portland cement with 5 - 30% sludge. After 28 days, the sludge and zeolite mixed Portland cement, which contained up to 10 % of SCM, obtained a higher or similar compressive strength as the reference specimen, while higher replacement levels reduced compressive strength. This should reduce the use of initial materials and the environment. Dry sludge from wastewater treatment plants is an alternative cement supplement by producing hardened cement paste samples. Binders that contain large amounts of additional cementing materials (SCM) have been the subject of interest for many years. Therefore, the quantity of Portland cement in the binder composition can be reduced and the negative impact of cement production can be reduced on the natural environment. It is important to reduce the consumption of Portland cement by simultaneously recycling by-product materials in order to avoid environmental problems and waste.

One SCM could be wastewater dry sludge. This type of by-product comes from returned daily concrete and laundry water for trucks and mixers. Wash water produces concrete by-products, such as high water content sludge and wastewater, after settlement. All types of such processing by-products can then be used to manufacture different low carbon footprint products to improve the sustainable development of the ready - mixed concrete industry as reported by Xuan et al. [43].

Sandrolini. [44] indicated that the mechanical strength of the recycled water-treated mortar and concrete was 28 days below 96 % of the reference materials. The filling effect of the washing water fines may be attributed to this effect.

Chatveera et al. [45] high alkalinity of sludge water has been determined and contributes to a more porous and weaker matrix. Kazaz et al. [46] presented current methods for the use of ready-mixed concrete returned: mixing with next matches, discharge into the settling basin, discharge to the ground, manufacture of precast concrete components, mechanical recycling, use of hardened slurry cake in concrete, use of hardened slurry cake in partition wall blocks, use of hydration stabilizer mixtures and Papí et al. supplements. [47]

Outlined the different recycling options for ready - mixed concrete plant products. The results showed that some percentages of the main properties improved when sand in concrete was replaced. It confirms the possibility of introducing more wash water into fresh concrete mixtures with sand correction depending on the water density. Audo et al. studied samples of ready-mixed concrete sludge plants [40].

Depending on the composition of the OPC, the synergistic effects of the use of several additional cement materials (SCM), such as Blast Furnace Slags plus Limestone Filler or Fly Ashes, were investigated. In longer hydration times, the mechanical strengths in ternary blends are higher with both OPCs and the formed C-S - H gels in al and C / S ratios are lower than in plain OPCs.

The aim of the study was to determine the influence of dry sludge from waste water concrete plants as cement supplementary material on the properties of hardened cement pastes specimens. Study of the crystalline components of the hardened cement paste specimens were examined by using X-ray diffraction analysis.

It showed that by substituting Portland cement with sludge additional two minerals: quartz and hydrotalcite were detected in the mineral composition of hardened cement paste specimens than those didn’t find in the reference specimens. Besides two new formed minerals there were calcite, ettringite, portlandite, alite, larnite and calcium silicate hydrate.

By increasing the sludge amount in the cement paste mixtures the main peaks belonged to ettringite and calcite increased, but portlandite peaks decreased in the mineral composition of hardened cement paste specimens.

The sludge interreacted with OPC minerals during hydration process and could be reason the formation of hydrotalcite and additional amount of the formation of ettringite.

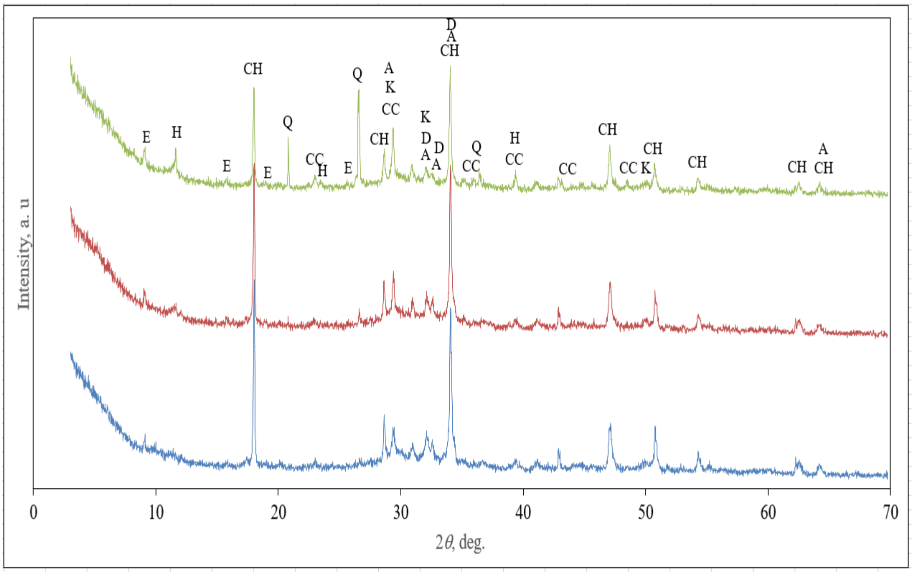

Figure 13 : X-Ray diffraction patterns of hardened cement paste specimens with 0%, 5% and 30% of sludge after 28 days

Notes: Q – quartz $SiO_2$ (78–1252), CC – calcite $CaCO_3$ (81–2027), E – ettringite $Ca_6Al_2(SO_4)3(OH)_{12}·26H_2O$ (41–1451), CH – portlandite $Ca(OH)_2$ (84-1265); A – alite $Ca_{54}MgA_{l2}Si_{16}O_{90}$ (13-272); D – larnite $Ca_2(SiO_4)$ (83-461); K – calcium silicate hydrate Ca1.5Si $O_3.5·x\ H_2O$ (33-306); H – hydrotalcite $((Mg_4A_{l2})(OH)12·CO_3(H2O)_3)0.5$ (70-2151.

Weerdt et al. [48] reserved interactions between calcareous powder and fly ash in ternary composite cement. Limestone powder interacts with AFM and AFt's hydration phases, which lead to the formation of carboaluminates at the expense of monosulphate and thus stabilize ettringite. The effect of calcareous powder on OPC may be limited by the limited amount of aluminum hydrates produced by the hydration of the OPC. Additional aluminates introduced into the system by fly ash amplify the effect of calcareous powder during its pozzolanic reaction.

This synergistic effect of calcareous powder and fly ash in ternary cement is confirmed in this study and results in improved mechanical properties which persist over time.

Notes: Q – quartz $SiO_2$ (78–1252), CC – calcite $CaCO_3$ (81–2027), Dl – dolomite $CaMg(CO_3)_2$ (84–1208), E – ettringite $Ca_6Al_2(SO_4)3(OH)_{12}\cdot 26H_2O$ (41–1451), CH – portlandite $Ca(OH)_2$ (84-1265); A – alite $Ca_{54}MgAl_2Si_{16}O_{90}$ (13-272); D – larnite $Ca_2(SiO_4)$ (83-461); K – calcium silicate hydrate Ca1.5Si O3.5·x H2O (33-306); H – hydrotalcite $((Mg_4Al_2)(OH)12\cdot CO_3(H_2O)_3)0.5$ (70-2151).

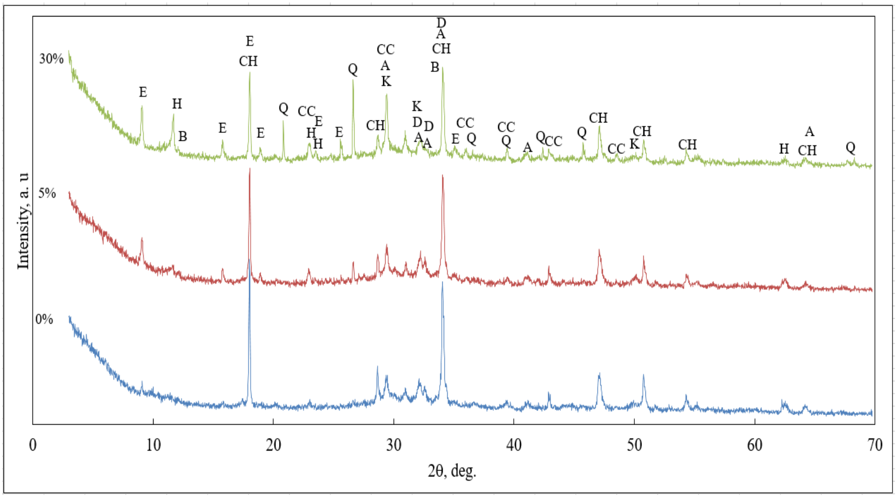

Figure 14: X-Ray diffraction patterns of hardened cement paste specimens with 5% of zeolitic waste and 0%, 5% and 30% of sludge after 28 days

In this work, we should do the compression test for mixing of cement paste and take the results. The test would be after 7 and 28 days from putting the cubes in the water, but here we have the result of for testing of cement paste after 7 and 28 days, and for cement paste with zeolitic after 7 days just. After the taking the measurement of concrete specimens (which are sent to a laboratory for testing) and Calculate the cross sectional area (unit should be on $mm^2$), and the load unit is generally in lb. we should be put down on paper.

### 4.1.1. The density and compressive strength with flexural strength of hardened cement paste

Table 4: The results of compressive strength and density of cement paste after 28 days for mixing without zeolite

| | b. (mm) | l. (mm) | h. (mm) | m. (g) | ρ. (kg/m^3) | σ. (MPa) | average, Mpa | average density |
|---|---|---|---|---|---|---|---|---|
| | 20,82 | 20,29 | 20,59 | 16,92 | 1945 | 77,95 | 68,83 | 1907,30 |
| **reference** | 20,51 | 21,37 | 20,67 | 16,83 | 1858 | 59,71 | | |
| | 20,5 | 20,64 | 20,1 | 16,32 | 1919 | 49,99 | | |
| | 21,35 | 21,75 | 21,87 | 17,84 | 1757 | 39,60 | 46,15 | 1766,33 |
| **5S** | 21,63 | 21,7 | 21,59 | 17,81 | 1757 | 46,15 | | |
| | 21,71 | 21,8 | 20,93 | 17,68 | 1785 | 39,91 | | |
| | 20,44 | 20,71 | 20,49 | 16,37 | 1887 | 52,02 | 56,38 | 1880,35 |
| **10S** | 20,71 | 20,64 | 20,42 | 16,4 | 1879 | 22,46 | | |
| | 20,39 | 20,43 | 20,64 | 16,12 | 1875 | 60,73 | | |
| | 21,6 | 20,95 | 21,16 | 17,23 | 1799 | 45,08 | 41,09 | 1777,59 |
| **20S** | 21,64 | 21,45 | 20,5 | 16,75 | 1760 | 29,23 | | |
| | 21,56 | 21,25 | 20,25 | 16,45 | 1773 | 37,11 | | |
| | 20,88 | 21,16 | 21,79 | 16,81 | 1746 | 27,34 | 27,34 | 1738,16 |
| **30S** | 21,1 | 21,18 | 21,36 | 16,82 | 1762 | 22,87 | | |
| | 21,16 | 21,34 | 21,7 | 16,72 | 1706 | 13,86 | | |

Table 5: The results of compressive strength and density of cement paste after 28 days for mixing with zeolite

| | b. (mm) | l. (mm) | h. (mm) | m. (g) | σ. (MPa) | ρ. (kg/m^3) | average, Mpa | average density |
|---|---|---|---|---|---|---|---|---|
| | 19,71 | 20,85 | 20,21 | 15,5 | 86,77 | 1866 | 86,99 | 1876,83 |
| **5S+Z** | 19,95 | 20,01 | 20,23 | 15,33 | 88,35 | 1898 | | |
| | 20,32 | 20,49 | 20,44 | 15,88 | 85,84 | 1866 | | |
| | 20,87 | 19,8 | 20,7 | 16,08 | 66,94 | 1880 | 68,11 | 1887,14 |
| **10S+Z** | 21,77 | 20,48 | 21,11 | 17,83 | 63,36 | 1894 | | |
| | 21,08 | 19,63 | 20,59 | 16,33 | 74,02 | 1917 | | |
| | 20,99 | 20,28 | 21,38 | 17,52 | 57,04 | 1925 | 47,29 | 1886,31 |
| **20S+Z** | 21,88 | 20,2 | 21,11 | 17,57 | 46,81 | 1883 | | |
| | 21,65 | 20,41 | 20,8 | 17,01 | 47,77 | 1851 | | |
| | 20,05 | 20,16 | 20,31 | 15,32 | 40,62 | 1866 | 43,14 | 1845,94 |
| **30S+Z** | 20,31 | 20,35 | 20 | 15,15 | 42,34 | 1833 | | |
| | 20,35 | 20,26 | 20,22 | 15,33 | 46,45 | 1839 | | |

Table 6: The results of compressive strength and density of cement paste after 7 days for mixing without zeolite

| **Nb** | **b. (mm)** | **l. (mm)** | **h. (mm)** | **m. (g)** | **σ. (MPa)** | **ρ. (kg/m^$^3$)** | **average, Mpa** | **average density** |
|---|---|---|---|---|---|---|---|---|
| **reference** | 20,4 | 20,2 | 20,4 | 16,08 | 65,30 | 1913 | 58,99 | 1891,82 |
| | 20,6 | 20,4 | 20,8 | 16,54 | 52,68 | 1892 | | |
| | 20,6 | 20,8 | 21 | 16,83 | 69,06 | 1870 | | |
| **5S** | 20,2 | 20,8 | 20 | 16,85 | 49,43 | 2005 | 47,66 | 1944,70 |
| | 20,4 | 21 | 20,8 | 17,09 | 45,19 | 1918 | | |
| | 20,2 | 21,7 | 21,5 | 18,01 | 48,36 | 1911 | | |
| **10S** | 20,4 | 20,2 | 20 | 16,08 | 58,31 | 1951 | 45,02 | 1900,03 |
| | 20,4 | 20,2 | 21 | 16,24 | 44,24 | 1877 | | |
| | 20,6 | 20,2 | 20,6 | 16,05 | 45,80 | 1872 | | |
| **20S** | 20,1 | 2,8 | 21 | 17,11 | 43,91 | 1951 | 32,93 | 1838,46 |
| | 20,6 | 21,9 | 21,2 | 16,8 | 29,37 | 1757 | | |
| | 20,2 | 21 | 21,2 | 16,26 | 36,49 | 1808 | | |
| **30S** | 20,4 | 20,2 | 21 | 15,87 | 32,25 | 1834 | 30,90 | 1782,87 |
| | 20,2 | 22,4 | 21,3 | 16,15 | 30,90 | 1676 | | |
| | 20,8 | 21 | 21,3 | 17,11 | 33,61 | 1839 | | |

Table 7: The results of compressive strength and density of cement paste after 7 days for mixing with zeolite

| | **b. (mm)** | **l. (mm)** | **h. (mm)** | **m. (g)** | **ρ. (kg/m^$^3$)** | **σ. (MPa)** | **average, Mpa** | **average density** |
|---|---|---|---|---|---|---|---|---|
| **5S+Z** | 20,45 | 20,73 | 20,43 | 16,17 | 1867 | 55,69 | 57,93 | 1882,97 |
| | 20,41 | 20,71 | 20,17 | 16,03 | 1880 | 62,65 | | |
| | 20,48 | 20,87 | 20,14 | 16,37 | 1902 | 55,45 | | |
| **10S+Z** | 21,32 | 20,31 | 21,4 | 16,87 | 1821 | 51,43 | 55,08 | 1875,46 |
| | 21,25 | 19,93 | 21,59 | 17,22 | 1883 | 58,98 | | |
| | 21,49 | 20,15 | 21,75 | 17,59 | 1868 | 54,82 | | |
| **20S+Z** | 20,42 | 20,29 | 21,34 | 16,54 | 1871 | 41,88 | 45,87 | 1855,36 |
| | 21,04 | 20,11 | 20,74 | 16,84 | 1919 | 44,03 | | |
| | 20,8 | 20,48 | 21,51 | 16,86 | 1840 | 51,72 | | |
| **30S+Z** | 20,08 | 21,08 | 20,2 | 15,27 | 1786 | 45,50 | 43,41 | 1814,57 |
| | 20,18 | 20,25 | 19,97 | 15,22 | 1865 | 44,00 | | |
| | 20,24 | 20,81 | 20,05 | 15,14 | 1793 | 40,74 | | |

The density of hardened cement paste specimen slightly decrease by increasing the sludge amount after 7 and after 28 days of hydration (Fig 15 a,b). The reduction in density values could be related with lover bulk density of sludge (668 kg/m$^3$) compared with bulk density of Portland cement (1236 kg/m$^3$). In that cases when ternary blended Portland cement (zeolitic by-product and sludge) were used the density was higher compared with the density of specimens which were made only from sludge and Portland cement.

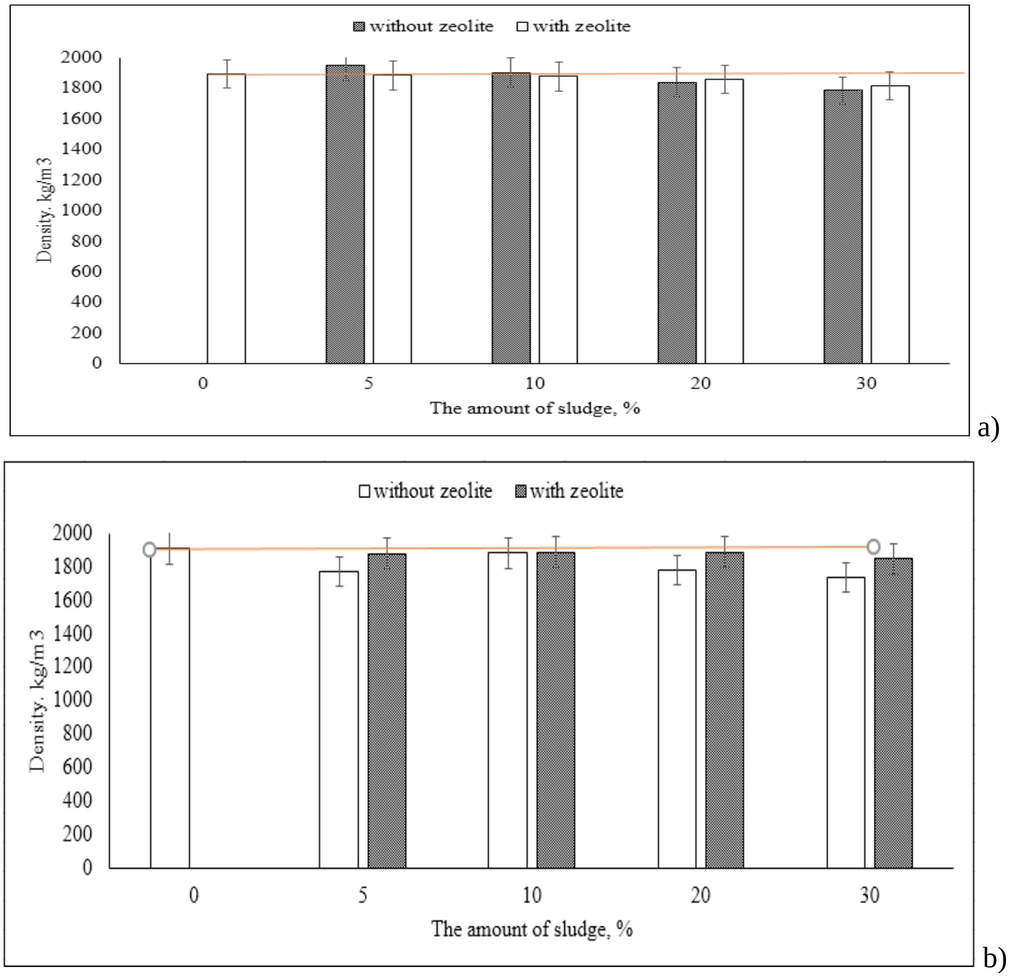

Figure 15: Density of hardened cement paste samples after 7 days (a) and after 28 days (b)

Compressive strength of the sludge blended Portland cement specimens decrease with increasing sludge powder replacement at all ages from 7 to 28 days.

Compressive strength of the sludge blended Portland cement specimens decreased with increasing sludge powder replacement at all ages from 7 to 28 days (Figure 16 a and b). After 7 days by using dry sludge from 5% until 30% in hardened cement paste, the compressive strength decreases gradually (Figure 16, a). It was 59 MPa for reference samples and the samples with 30% of dry sludge had 31 MPa. It consists almost two times lower compressive strength compared with reference samples. Different situation was when zeolitic waste was inserted in the mixtures. The samples with zeolitic waste had higher compressive strength comparing with samples without zeolitic waste. The sludge and zeolitic waste blended Portland cements containing up to 5% of both SCM obtain a similar compressive strength as the reference after 7 days, while higher replacement levels lead to a reduction in compressive strength.  Similar situation was following 28 days of hydration (Figure 16, b). In all samples compressive strength decreased by increasing sludge amount. Distinctive circumstance was for the situation when sludges  and  zeolitic waste was used as SCM. The zeolitic waste and sludge  squander mixed Portland cement containing up to 5% of supplementary cementing materials SCM acquired a higher compressive strength as the reference specimen after 28 days, while higher substitution levels lead to a decrease in compressive strength. Up to now, dry sludge from waste water concrete as submitted by Audo et. al [40].

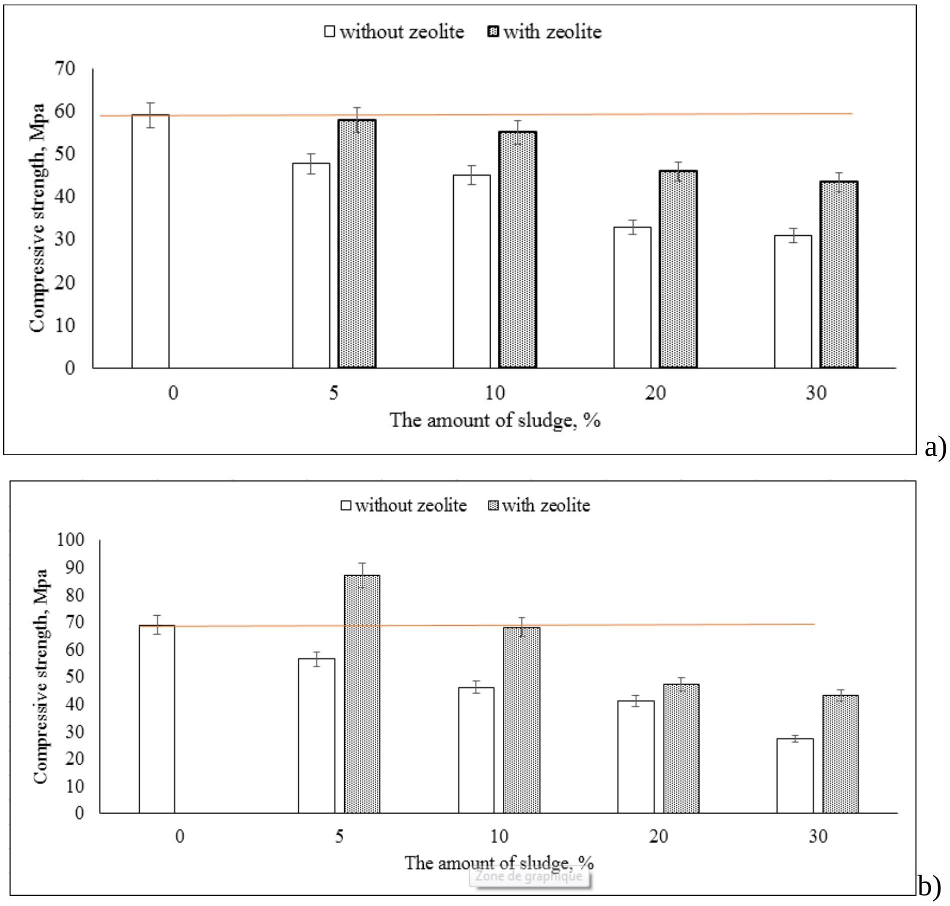

Figure 16: Compressive strength of hardened cement paste samples after 7 days (a) and after 28 days (b)

Different situation was when zeolitic waste was inserted in the mixtures of cement paste. The ternary blended Portland cement specimens had higher compressive strength comparing with samples without zeolitic waste at 7 days and at 28 days. Specimens with 30% of SCM had 27% reduction in compressive strength after 7 days (Figure 16, a). After longer time hydration, at 28 days, the ternary blended Portland cement specimens wih 5% of SCM obtained the increase of 20.7% in compressive strength compared with the reference specimens. Higher replacement levels lead to a reduction in compressive strength. Specimens containing 10% of SCM obtained similar compressive strength as the reference specimen after 28 days, while higher replacement levels lead to a reduction in compressive strength (Figure 16,b).

### 4.1.2. Consequence

The density of hardened cement paste specimen slightly decrease by increasing the sludge amount in the mixtures. In that cases when sludges with 5% of zeolitic waste were used as supplementary cementing materials (SCM) the density was close to the reference specimen density or it insignificant decreased.

Compressive strength of the sludge blended Portland cement specimens decreased with increasing sludge powder replacement. Different situation was when zeolitic waste was inserted in the mixtures. The specimens had higher compressive strength comparing with samples without zeolitic waste. The sludge and zeolitic waste blended Portland cements containing up to 10% of SCM obtained a higher or similar compressive strength as the reference specimen after 28 days, while higher replacement levels lead to a reduction in compressive strength.

## 4.2. Maine properties of concrete with addition of dry sludge from waste water concrete plants

The paper describes an investigation of the the use of dry sludge from waste water concrete plants as an additive for concrete, for which it must be guaranteed that the resulting concrete has the appropriate mechanical strength and durability. In earlier our work it was investigated the hardened cement paste specimens with dry sludge from waste water concrete plants instead of Portland cement. It was shown that the addition of sludge reduces the mechanical strength of concrete, but the complex addition of this sludge and zeolitic waste improve mechanical properties of hardened cement paste specimens. With the addition of 10% sludge and 5% zeolitic waste in the hardened cement paste specimens, the mechanical strength remaisned close to reference specimens.

In this chapter concrete specimens were investigated. It were chosen 4 types of diferent composition by changing the amount of Portland cement with sludge (5%, 10% and 20%) and zeolitic waste of 5% (Table 8).

Table 8 : Composition of 1 m3 of concrete mixtures (concrete mix design was calculated by the absolute Volume Method). Materials content for 1m$^3$ of concrete mixture should be recalculated

| Specimens | Binding materials | | | Sand Kg/m$^3$ | Gravel Kg/m$^3$ | Supper plasticizer g/m$^3$ | $H_2O$ L/m$^3$ | W/C |
|---|---|---|---|---|---|---|---|---|
| | Cement Kg/m$^3$ | Sludge Kg/m$^3$ | Zeolite Kg/m$^3$ | | | | | |
| First reference: | 350 | 0 | 0 | 861 | 1031 | 3.5 | 157.50 | 0.41 |
| Second reference: | 328.125 | 17.5 | 17.5 | 861 | 1031 | 3.5 | 157.50 | 0.41 |
| Third reference: | 297.50 | 35 | 17.5 | 861 | 1031 | 3.5 | 157.5 | 0.41 |
| Fourth reference: | 243.055 | 59.59 | 17.5 | 861 | 1031 | 3.5 | 3157.5 | 0.41 |

Concrete is a composite material consisting of a binder, which is typically rough, cement and fine aggregates, which are usually sand and gravel. but here we must put half of mixing waste water and water.  These comprise the constituent materials of concrete.  But because of the many variables of the raw materials and how they are processed and combined, there are many opportunities for problems to appear in concrete.

### 4.2.1. compressive strength after 28 days

Table 9: compressive strength of concrete specimens after 28 days under water

| | b. (mm) | l. (mm) | h. (mm) | m. (g) | ρ. (kg/m^$^3$) | σ. (MPa) | average, Mpa | average density |
|---|---|---|---|---|---|---|---|---|
| reference | 100,1 | 100,67 | 100 | 2429,4 | 2411 | 60 | 60,49 | 2400 |
| | 99,12 | 100 | 99,9 | 2370,7 | 2394 | 64 | | |
| | 100,09 | 99,92 | 100,01 | 2395,6 | 2395 | 58 | | |
| 1 | 98,48 | 100,09 | 100,97 | 2361 | 2372 | 60 | 61,66 | 2382 |
| | 99,99 | 98,29 | 100,12 | 2366,4 | 2405 | 63 | | |
| | 99,53 | 100,35 | 99,91 | 2364,9 | 2370 | 62 | | |
| 2 | 99,94 | 100,15 | 100,41 | 2401,1 | 2389 | 58 | 57,58 | 2374 |
| | 99,8 | 100,18 | 99,96 | 2370,8 | 2372 | 57 | | |
| | 100,35 | 100,32 | 100,73 | 2411,8 | 2378 | 58 | | |
| | 100,2 | 100,07 | 100,64 | 2377,7 | 2356 | 57 | | |
| 3 | 100,86 | 100,03 | 100,03 | 2398,5 | 2377 | 52 | 49,64 | 2355 |
| | 101,1 | 100,8 | 100,03 | 2409,9 | 2364 | 50 | | |
| | 100 | 100,35 | 99,8 | 2355,1 | 2352 | 50 | | |
| | 99,48 | 100,94 | 100,62 | 2351,6 | 2327 | 47 | | |

First, the effect of SCM amount on the density of concrete was determined. The density of specimens remains close to reference specimen’s density or it slightly decreased with the increasing the amount of SCM in concrete composites (Figure 17). Slightly reduction of density in investigated concrete specimens could be explained by a lower bulk density of sludge (668 kg/m3) and zeolitic waste (864 kg/m3) compared with the density of Portland cement (1236kg/m3).

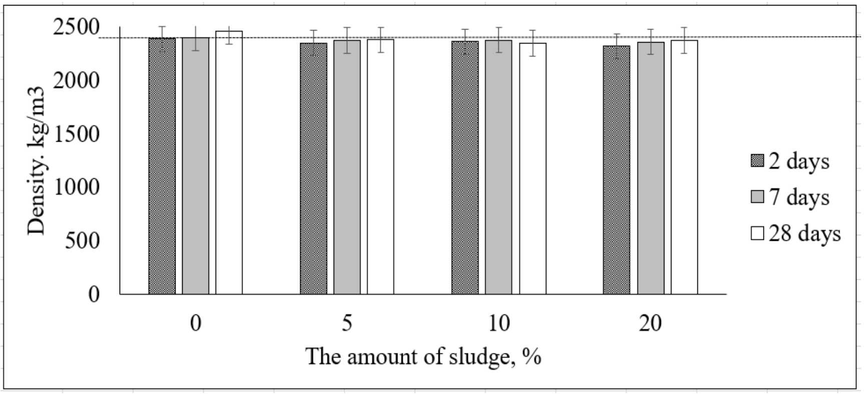

Figure 17 : The influence of the amount of sludge on concrete specimen’s density after 2, 7 and 28 days of hardening

The effect of SCM amount on compressive strength, of concrete specimens is significant. After 2 and 7 days of hydration concrete specimens containing SCM exhibited compressive strength than concrete spacemen without SCM (Figure 18, a). Situation was changed after 28 days of hydration. Specimens with 5% of sludge and 5% of zeolitic waste had for 3.3 % higher compressive strength than reference specimens.

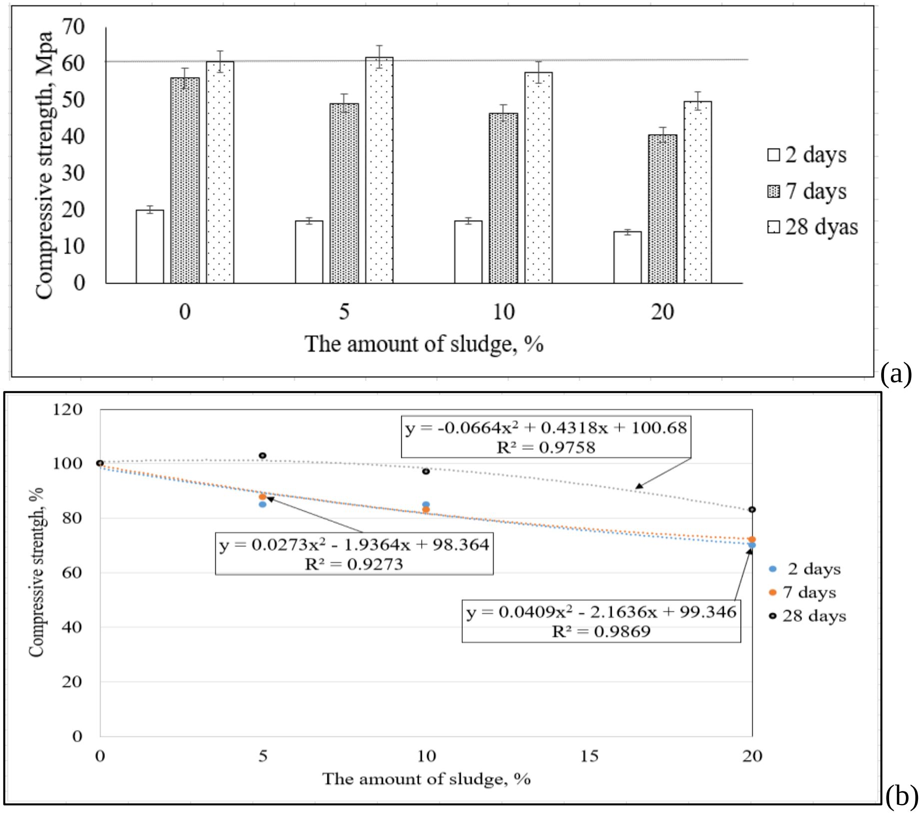

Figure 18: The influence of the amount of sludge on the compressive strength of concrete specimens in MPa (a) and in % (b)

The change of the compressive strength with the addition of different amounts of SCM could be mathematically described by the multivariate equation of second degree (Figure 18, b).

### 4.2.2. Full absorption water

#### Drying samples

To determine the sample’s water absorption firstly all cubes concrete put in oven for 3 days at temperature approximately 100$^{o}$C. A sample of at concrete samples are dried in an oven to constant mass after being. After removal from the oven the sample’s mass is registered then the measure token by using scale (Figure ).

In this test the sample is submerged and the evolution of the hydrostatic mass is measured using a scale. It takes 24 hours and the increase of the hydrostatic mass during that period corresponds to the concrete’s water absorption.

Table 10 : measure of concrete cubs of full absorption water

| mark | dry mass, g | Masse 15 m | Masse 1h | Masse 24h | Masse 48h | Mass in water |
|---|---|---|---|---|---|---|
| Reference | | | | | | |
| 1 | 543,24 | 558,12 | 564,13 | 571,69 | 572,39 | 334,76 |
| 2 | 521,51 | 535,22 | 540,36 | 547,05 | 547,36 | 383,84 |
| 3 | 604,13 | 619,29 | 626,7 | 633,46 | 634,45 | 372,45 |
| 4 | 648,75 | 662,75 | 669,75 | 677,79 | 678,25 | 401,94 |
| one: | | | | | | |
| 1 | 532,04 | 547,45 | 554,88 | 562,28 | 562,85 | 227,02 |
| 2 | 581,49 | 597,15 | 604,11 | 612,54 | 612,91 | 358,03 |
| 3 | 605,13 | 615,88 | 623,08 | 631,4 | 631,94 | 375,29 |
| 4 | 579,12 | 595,79 | 602,54 | 610,65 | 611,28 | 357,87 |
| two | | | | | | |
| 1 | 509,52 | 521,65 | 529,35 | 537,44 | 537,71 | 310,8 |
| 2 | 543,66 | 556,7 | 564,48 | 573,35 | 573,79 | 329,7 |
| 3 | 433,08 | 444,2 | 450,37 | 456,55 | 456,34 | 227,28 |
| 4 | 649,93 | 663,51 | 672,21 | 682,49 | 682,98 | 399,94 |
| three | | | | | | |
| 1 | 598,27 | 613,46 | 621,63 | 630,31 | 630,79 | 367 |
| 2 | 596,47 | 609,89 | 619,35 | 628,3 | 629,23 | 367,42 |
| 3 | 490,24 | 503,28 | 509,76 | 517,32 | 517,63 | 301,67 |
| 4 | 485,66 | 500,5 | 507,9 | 512,59 | 513,32 | 295,03 |

## Porosity parameters of concrete

With the increase of sludge in fresh concrete the frost resistance increases after 28 days of hardening because the closed porosity of hardened cement increases.

( Figure 24) illustrates frost resistance parameters Kf of concrete samples.

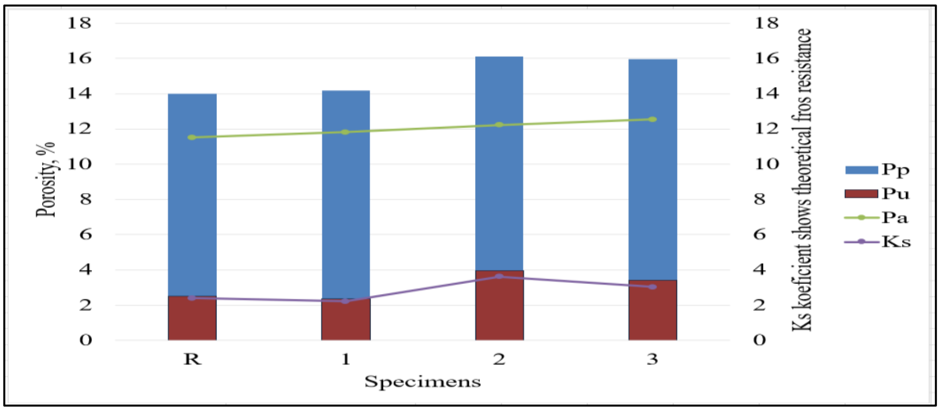

Figure 19 : Dependence of frost resistance factor Kf, open porosity Pa and closed porosity Pu on the amount of sludge with 5% of zeolitic waste. Notes: Pp-full porosity in concrete. Ks coefficient shows theoretical frost resistance - amount of heating cooling cycles

Figure 24 illustrated parameters of frost resistance Ks of concrete specimens of different SCM quantities and dependence on closed porosity Pu, open porosity Pa of SCM quantity. Increasing the amount of additional cementing materials (SCMs) in the concrete composition increases the frost resistance after 28 days of hardening. These values were closely related to the increased values of closed porosity of concrete (Figure 24). The closed porosity of reference specimens was 2.5% and increased to 3.43% for specimens with 20% sludge and 5% zeolite waste (Fig. 24).

The closed porosity created reserve pores and increased freezing resistance of concrete specimens, as Skripkiunas et al. indicated[49].

Table 11: table of porosity

| | Pp | Pa | Pu | Ks |
|---|---|---|---|---|
| R | 14 | 11,51 | 2,5 | 2,4 |
| 1 | 14,19 | 11,82 | 2,37 | 2,22 |
| 2 | 16,12 | 12,22 | 3,97 | 3,62 |
| 3 | 15,97 | 12,55 | 3,43 | 3,03 |

The results obtained from the diagrams have shown that concrete closed porosity, which creates reserve pores and increases frost resistance of the concrete, reaches 2.5 – 3.43% in samples with different sludge samples. Smaller size of sludge increase closed porosity and frost resistance of hardened concrete. As concrete's porosity is closely related to air entrainment in the fresh concrete and the porosity value usually is slightly lower than the air entrainment value, we may assume that with higher rubber waste content in fresh concrete the concrete has higher freeze-thaw resistance. According to the theory of hydraulic pressure concrete frost resistance depends on its open (capillary) and closed porosity. During the test the w/c ratio was the same, therefore the capillary porosity of the concrete did not change much. Subsequently, in our case the frost resistance of the concrete depends only on the closed porosity. The frost resistance factor Ks, computed from open and closed porosity of the concrete, ranges from 2.4 in non-rubberized concrete to 3.03 in concrete modified. From the frost resistance factor we may predict that concrete with rubber admixtures has frost resistance of about 100 – 600 freeze-thaw cycles, when concrete is soaked in salt solutions.

### 4.2.3. Flexural test

In flexural test, preparing 8 samples of concrete, 2 samples from each type, this test has 4 tests are references 0% sludge, 5 % sludge, 10 % sludge and 20 % sludge.

**Results of flexural materials**

Table 12: results of flexural materials

| | b | h | L | F Kn | √m Mpa | flexural Mpa | Average |
|---|---|---|---|---|---|---|---|
| R | 101,8 | 100,64 | 250 | 18,17 | 6,61 | 6,61 | 6,17 |
| R,1 | 101,22 | 100,63 | 250 | 15,64 | 5,72 | 5,72 | |
| 1 | 99,01 | 100,77 | 250 | 16,06 | 5,99 | 5,99 | 5,59 |
| 1,1 | 101,23 | 100,58 | 250 | 14,19 | 5,2 | 5,20 | |
| 2 | 100,11 | 99,51 | 250 | 18,6 | 7,04 | 7,04 | 6,24 |
| 2,1 | 101,91 | 96,59 | 250 | 13,79 | 5,44 | 5,44 | |
| 3 | 99,69 | 100,55 | 250 | 15,23 | 5,67 | 5,67 | 5,69 |
| 3,1 | 95,76 | 101,47 | 250 | 15,02 | 5,71 | 5,71 | |

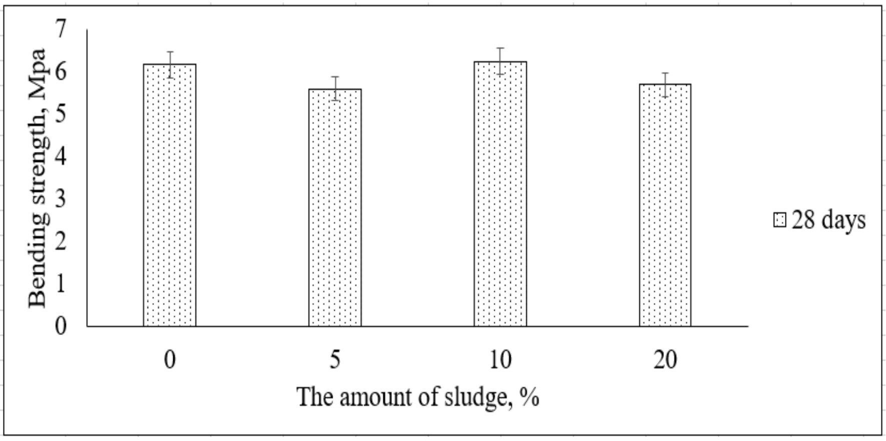

Figure 20: The influence of the amount of sludge on the flexural strength of concrete specimens

Figure 30 shows the flexural strength values. As expected, the flexural strength slightly decreased by increasing the amount of SCM. It changed from average 6.08 MPa for the control specimens to 3.67 MPa for the concrete specimens containing 20% of SCM.

### 4.2.4. Consequence

The density of the reference specimen remained close to or decreased slightly with the increase in the amount of SCM in concrete mixtures by using additional cementing materials (sludge and zeolite waste) in the density of the concrete specimen. It can be connected to a lower density of SCM than the cement density of Portland.

Supplementary cementing materials affected the compressive strength of concrete specimens. After 2 and 7 days of hydration concrete specimens containing SCM exhibited lower compressive strength than concrete spacemen without SCM. Situation was changed after 28 days of hydration. Specimens with 5% of sludge and 5% of zeolitic waste had for 3.3 % higher compressive strength than reference specimens. On the contrary after 28 days specimens with 5% of sludge and 5% of zeolitic waste had for 3.3 % higher compressive strength than reference specimens.

The flexural strength of concrete specimens slightly decreased by increasing the amount of SCM. It changed from average 6.08 MPa for the control specimens to 3.67 MPa for the concrete specimens containing 20% of SCM.

The frost resistance increased slightly after 28 days of hardening by increasing the quantity of additional cementing materials (SCM) in the concrete composition. These values have been closely linked to closed concrete porosity values, which have also increased. The closed porosity of the reference specimens was 2.5% and for specimens with 20% sludge and 5% zeolite waste increased to 3.43%.

# Conclusion

1- When sludge with 5% of zeolitic waste were used as supplementary cementing materials (SCM) the density was close to the reference specimen density or it insignificant decreased. Compressive strength of the sludge blended Portland cement specimens decreased with increasing sludge powder replacement. The sludge and zeolitic waste blended Portland cements containing up to 10% of SCM obtained a higher or similar compressive strength as the reference specimen after 28 days, while higher replacement levels lead to a reduction in compressive strength.

2- By using of supplementary cementing materials (sludge and zeolitic west) in concrete specimen's density remained close to reference specimen's density or it slightly decreased with the increasing the amount of SCM in concrete mixtures. It could be related with a lower density of SCM compared with the density of Portland cement. After 28 days specimens with 5% of sludge and 5% of zeolitic west had for 3.3 % higher compressive strength than reference specimens. The flexural strength of concrete specimens slightly decreased by increasing the amount of SCM.

3- By increasing the amount of supplementary cementing materials (SCM) in the composition of concrete specimens the frost resistance slightly increased after 28 days of hardening. These values closely related with the values of closed porosity of concrete which increased as well. The closed porosity of reference specimens was 2.5% and it was increased until 3.43% for specimen with 20% of sludge and 5% of zeolitic west.

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