RESEARCH ARTICLE OPEN ACCESS

Use of kitchen Waste (Carrot/Potato Peeling) in Fast Set Cement Mortar

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Executive summary

This research began on a quest to establish replacement of cement with kitchen waste. In the first semester the proposal of my project was based on eggshell replacement of cement, but upon extensive literature review, it was gathered that only 5-15% of the initial material can be used on cement. Therefore the supervisor and I ruled out the possibility of using eggshells as it was gathered that only a small percentage of 5% can be utilized, our objective was to replace a large percentage of cement with eggshells. A new idea was developed to use carrot and potato peelings on virtue of reducing kitchen waste material.

This paper will explore the possibilities of the usage of carrot and potato peelings into fast set cement mortar, as an experiment was modulated and carried out this semester for the testing of the cement mortar and carrot/ potato peelings for the compatibility and strength tests and the results are analysed at the end of the testings to gather the full potential and critical study of carrot/potato peelings and concrete mix possibilities.

Globally waste products are polluting the environment. There are multiple methods of waste disposal system such as incineration, land fill dumping or reusing items and making other products if there are potentials. Potato and carrot peelings have been identified in this study as a potential partial replacement in fast set cement mortar as means to reduce cost of

concrete production by in-cooperating a foreign material into the mixture.

Experimentation was designed to gather results and data on how much potato and carrot peelings per percentage are compatible with cement mortar of a particular type (fast set cement).

The aim of this study was to establish the compatibility and compressive strength of the carrot andpotato peelings to find its suitability of replacement in the fast set cement mortar. To examine the feasibility of utilising the carrot and potato peelings as cement replacement material. To study the strength parameters of the potato and carrot peeling powder mixed specimens and to compare it with conventional specimens. The scope of the study was to cast the concrete specimens and conduct the compressive strength test, at 7^{th}day, with the specified combinations of potato and carrot peeling powder and compare it with the controlled concrete specimens.

Initially it was discussed with the supervisor to replace a large percentage of cement potato with thepeeling powder, therefore 25%, 35% and 50% was replaced and it was gathered that the specimen was extremely brittle and would not be suitable to undergo a compressive strength test

Based on the literature review of previous similar experimentation, 5% cement replacement with foreign material are highly compatible therefore 5%, 10% and 15% was used in my project as it has shown to give optimal results with that percentage replacement with concrete

Introduction/Statement of problem

Energy plays a crucial role in growth of developing countries like Australia. In the context of low availability of non-renewable energy resources coupled with the requirements of large quantities of energy for Building materials like cement, the importance of using industrial waste cannot be under estimated. During manufacturing of one tonnes of Ordinary Portland Cement we need about 1.1 tonnes of earth resources like limestone, etc. Further during manufacturing of 1 tonnes of Ordinary Portland Cement an equal amount of carbon-di-oxide are released into the atmosphere. The carbon- di-oxide emissions act as a silent killer in the environment as various forms. In this Backdrop, the search for cheaper substitute to GPC is a needful one.

Calcium rich egg shell is a poultry waste with chemical composition nearly same as that of limestone. Use of eggshell waste instead of natural lime to replace cement in concrete can have benefits like minimizing use of cement, conserving natural lime and utilizing waste material. Yerramala (2014)

.According to a study eggshell waste generation in Australia, the United States and the United Kingdom is 190000, 150000 and 11000 tonnes per annum respectively. Eggshell waste can be used as fertilizer, animal feed ingredients and other such uses. However, majority of the eggshell waste is deposited as landfills. Eggshell waste in landfills attracts vermin due to attached membrane and causes problems associated with human health and environment. Few investigations were conducted to use eggshell waste in civil engineering applications. Amu et al(2001)., studied eggshell powder as a stabilizing material for improving soil properties.Olarewajuet al (2011) studied suitability of eggshell stabilized soil as subgrade material for road construction. Apart from these studies, no other investigations were found in literature to use eggshells in civil engineering applications.

Therefore, to initiate use of eggshell waste for partial replacement of cement in concrete, there is a need to understand concrete properties made with eggshell powder. Thus, the primary objective of this study is to understand the possibilities of use of ESP in concrete. Investigations will be systematically conducted on performance of ESP concretes in terms of strength properties like compressive strength, splitting tensile strength and flexural strength test. The control and ESP replaced concretes will be tested for 7, 14 and 28 days. Based on the test results, the influence of ESP replacement and the curing age on the concrete properties will be further discussed.Taking in account the research already carried the objectives of this study are to quest for the answer of following questions,

1- What is the effect of partial replacement of cement with eggshell waste on the compressivestrength of concrete?

2- What is the effect of partial replacement of cement with eggshell waste on the splittingtensile strength of concrete?

3- What is the effect of partial replacement of cement with eggshell waste on the flexuralstrength of concrete?

4- What is the effect of partial replacement of cement with eggshell waste on the waterpenetration properties of concrete?

Background and literature review

Upon discussion with the supervisor in charge of my capstone project, the initial proposal and goal of the report was further modified, as it was gathered that the designated eggshell replacement withcement can only cater for 5-15% replacement, as according to the findings of the last report, the supervisor pointed out that 5-15% replacement for optimal strength in the cement /eggshell mixture is not sufficient as it is only a small percentage of the eggshell powder which can be utilized in the project. To his validity, a larger percentage of material/ ingredient which is capable to replace a large portion of cement will be of great benefit for cement replacement, therefore it was gathered to use food waste as a replacement materials in the design.

According to the literature Review on my established research topic which was eggshell replacement on cement in concrete mortar from last semester, it was gathered that only a small percentage of around 5% eggshell can be used in cement replacement and as the research on this material with certified validation has already been gathered on the optimality via experimentation, the supervisor and I have discussed to test food waste materials which will be potato peelings and carrot peelings in particular for testing as a foreign element in the cement mortar. These particular materials were discussed to be used due to the uniqueness of having no previous research on cement mixture with these materials. The literature review on the related foreign food waste and food material will be presented in the next few paragraphs.

Literature Review

Below are some of the food, food waste and agricultural materials which will be presented based onthe compressive strength, replacement percentages and results upon the usage of the foreign material in the concrete mix design.

Review on Eggshells:

Amarnath Yerramala(2014) studied the Properties of concrete with eggshell powder as cement replacement. This paper describes research into use of poultry waste in concrete through the development of concrete incorporating eggshell powder (ESP). Different ESP concretes were developed by replacing 5-15% of ESP for cement. The results indicated that ESP can successfully be used as partial replacement of cement in concrete production. The data presented cover strength development and transport properties. With respect to the results, at 5% ESP replacement the strengths were higher than control concrete and indicate that 5% ESP is an optimum content for maximum strength. In order to investigate properties of ESP concretes, five mixes were employed in this study. Several laboratory trial mixes were carried out with 300kg/m3 cement. Water to cement ratio, coarse and fine aggregate quantities was arrived for concretes to be tested from the trial mixes. In this study, Compressive loading tests on concretes were conducted on a compression testing machine of capacity 2000 KN. For the compressive strength test, a loading rate of 2.5 kN/s was applied. The test was conducted on 150mm cube specimens at 1, 7 and 28 days. Compressive strength was higher than control concrete for 5 % ESP replacement at 7 and 28 days of curing ages.

ESP replacements greater than 10 % had lower strength than control concrete. Addition of fly ashimproved compressive strength of ESP concrete.

D.Gowsika et al(2014) experimentally investigated the Egg Shell Powder as Partial Replacement with Cement in Concrete. This paper reports the results of experiments evaluating the use of egg shell powder from egg production industry as partial replacement for ordinary Portland cement in cement mortar. The chemical composition of the egg shell powder and compressive strength of the cement mortar was determined. The cement mortar of mix proportion 1:3 in which cement is partially replaced with egg shell powder as 5%, 10%, 15%, 20%, 25%, 30% by weight of cement. The compressive strength was determined at curing ages 28 days. There was a sharp decrease in compressive strength beyond 5% egg shell powder substitution. The admixtures used are Saw Dust ash, Fly Ash and Micro silica to enhance the strength of the concrete mix with 5% egg shell powder as partial replacement for cement. In this direction, an experimental investigation of compressive strength, split tensile strength, and Flexural strength was undertaken to use egg shell powder and admixtures as partial replacement for cement in concrete.

Praveen Kumar R et al(2015) experimentally investigated the Partial Replacement of Cement with Egg Shell Powder. The aim of this study is to study the chemical composition of the egg shell to find its suitability of replacement in the concrete. To examine the feasibility of utilizing the egg shell and silica fume as cement replacement material. To study the strength parameters of the egg shell powder mixed specimens and to compare it with conventional specimens. The scope of the study is to cast the concrete specimens and conduct the compressive strength test, split tensile strength test and flexural strength test at 7th & 28thday, with the specified combinations of egg shell powder and compare it with the controlled concrete specimens. In this project M30 Concrete is designed for various combinations. A combination of Egg shell with silica fumes are used in different combinations to find the feasibility of using the Egg shells as an alternate to cement Egg shell powder replaces 10%, 20% and 30% in addition with the silica fume by 5%, 10%, 15% of weight of cement. Concrete is cast and Compressive test, Tensile and Flexural tests were carried out to find the best combination which results in optimum percentage of strength.

Freire et al (2006) carried out the investigation on egg shell waste and found out its use in a ceramic wall tile paste. Based on the presence of CaCO3 in egg shell it can be used as a alternative raw material in the production of wall tile materials they Also found that egg shell can be used as an excellent alternative for material reuse and waste recycling practices.

Lau yih bling(2010) conducted the investigation in egg albumen and reported that foamed concrete were prepared by egg albumen which has reduce the cost and time of project. 1 per cent and 5 per cent egg albumen were used. From the investigation it is concluded that 5 per cent of EAFC consists of unstable compressive strength and higher flexural strength with increased density when compared with control foamed concrete which was 64 per cent and 35 per cent. In this study it is proved that Egg Albumen Foamed Concrete (EAFC) can produce light weight concrete which is moreenvironment friendly and improved properties.

Amu et al(2001) carried out the experiment and stated that common salt with egg shell on lateriticsoil obtaining a good compliment for egg shell as a useful stabilizer for road works. Stabilization obtained by adding 2-10 per cent of common salt with optimum egg shell powder. The result showed that the addition of common salt improved the compaction and CBR characteristics of eggshell stabilized soils.

Ngo slew kee(2010) investigated on the topic of effect of coconut fiber and egg albumen in mortarfor greener environment and reported the effect of coconut fiber and egg albumen on mortar compressive and flexural strength. 3 types of samples were tested to compare the strength
development of each other's that was mortar control, mortar containing 0.1 per cent coconut fiber with 1 per cent egg albumen and mortar containing 0.5 per cent coconut fiber with 5percentegg albumen. The strength of mortar containing 0.1 per cent coconut fiber with 1 per cent egg albumen was higher than the mortar control whereas the mortar containing 0.5 percent coconut fiber ± 5 per cent egg albumen was lower strength than the mortar control. The strength of mortar containing 0.1per cent coconut fiber with 1 per cent egg albumen was higher than the mortar control whereas the mortar containing 0.5 per cent coconut fiber ± 5 per cent egg albumen was lower strength than the mortar control.

Okonkwo et al(2012) has concluded in his research that Egg Shell ash can be used as an alternate for cement which resulted in higher compressive strength on lateritic soil. Constant Cement of 6 and 8 per cent added with the egg ash powder of 0-10 per cent at 2 per cent intervals shows increase in 35 per cent of compressive strength but fell short of the strength requirements the durability.
Ultimately they found that soil-cement egg shell mixture can be used for road pavements.

Arash Barazesh et al(2012) carried out the experiment on the effect of eggshell powder on plasticity index in clay and expansive soils and reported that plasticity index of the soil can be improved by adding egg shell wastes with the clay soil and can be used in construction projects including earth canals and earth dams.

Monisha T (2016) experimentally investigated the concrete using eggshell powder and polypropylene fibre. The food processing industries, hotels and restaurants are the places produces egg shell waste abundantly. Dumping of egg shell waste creates odour and various diseases. In order to overcome this problem we have to dispose the egg shell waste safely without environmental hazards. As a result, utilization of //egg shell waste in the concrete has developed. The aim of this project work is to use egg shell powder 20% constantly as replacement of fine aggregate and to use polypropylene fibre in the range of 0%, 0.2%, and 0.4% in the M20 concrete by the volume of fraction. Various tests such as compressive strength, split tensile strength and flexural strength were carried out. The strength properties obtained were compared with the conventional concrete after the curing period of 7, 14 and 28 days. From the results it was observed that, the waste of egg shell powder used in the concrete will be comparatively low cost when compared with normal concrete.

Dinesh et al(2001) has conducted the experiment by replacing fine aggregate by rice husk ash and egg shell powder. Here they had replaced the Egg shell up to 10%, 20%, 30%, 40% & 50% using M25 grade concrete. They had conducted test for 7 days, 14 days and for 28 days. Based on the analysis in the present experimental work, they had concluded that the tensile strength, flexural strength was decreased with increasing egg shells percent. The compressive strength of the concrete is to meet required strength with 20% of the egg shell at the same time weight of the cubes are reducedupto 2kg to 2.8kg.

Jayasankar et al(2010)has investigated the experiment by partially replacing cement with fly ash and egg shell powder. They had conducted experiment by varying percentage of RHA, ESP, Fly ash in M20, M25 and M30 concrete. Based on the results obtained from the experiment it can be concluded that, RHA, Fly ash and ESP mixed cubes has equal strength with that of conventional concrete cubes in certain categories.

Karthick et al (2012)has conducted experiment by replacing the fine aggregate by egg shell. Here they had replaced the Egg shell up to 10%, 20%, 30%, 40% & 50%. They concluded that, the tensile strength, flexural strength was decreased with increasing egg shells percent. The tensile strength decreased from (2.36N/mm2) to (0.21 N/mm2) with increasing egg shell from (0 wt %) to (50 wt %).

Mahendra Prasad et al (2013) had done the research to investigate the workability and flexural strength of cement concrete containing silica fume and polypropylene fibers. Silica fume content used was 0%, 5%, 10% and 15% by replacement of equal weight of cement in concrete.
Polypropylene fibers were added in 0%, 0.20%, 0.40% and 0.60% by volume fraction of concrete. Silica fume appeared to have an adverse effect on the workability of fiber concrete. It is observed from slump test results of PF0S0 to PF0.6S15 that there is continuous decrease in workability of concrete with increase in polypropylene fiber content. The increase in flexural strength was found to be around 40% with the use of polypropylene and silica fume compared to the reference concrete.

Praveen Kumar et al (2015) has investigated the combination of Egg shell with silica fumes are used in different combinations to find the feasibility of using Egg shell as an alternate to cement. Egg shell powder replaces 10%, 20% and 30% in addition with the silica fume by 5%, 10%, and 15% of weight of cement in the M30 concrete. The compressive strength of concrete with egg shell powder increases up to 15 percent without silica fume. Addition of silica fume also enhances the strength but in economical point of view only the egg shell powder replacement is sufficient enough for getting higher strength. The split tensile strength of the egg shell powder concrete decreases with the addition of egg shell powder. The flexural strength of the egg shell concrete increases with the addition of egg shell powder up to 15 precent.

Review On Kitchen Waste :
<u>Bagasse ash</u>
Researchers (Modani and Vyawahare, 2013; Shafana and Venkatasubramani, 2014; Shah et al., 2014) have conducted the compressive strength of bagasse ash concrete as per IS 516: 1959 (Indian Standard, 1959). Concrete using sugarcane bagasse ash as fine aggregate shows an increasing compressive strength at 10% replacement than the control concrete, but further increase of bagasse ash decreased the strength as reported by Modani and Vyawahare (2013). Shafana and Venkatasubramani (2014) reported the same result with sugarcane bagasse ash concrete in which compressive strength improved by increasing the curing period. Fig. 12(a) and (b) represents the compressive strength of bagasse ash concrete in different mix proportions and curing periods. In case of M25 (Shah et al., 2014) and M30 (Shafana and Venkatasubramani, 2014) grade of concrete, it can be observed that concrete achieved its minimum compressive strength at 20% replacement of bagasse ash. Almeida et al. (2015) reported that the use of sugarcane bagasse ash as fine aggregate did not affect the compressive strength of mortar.

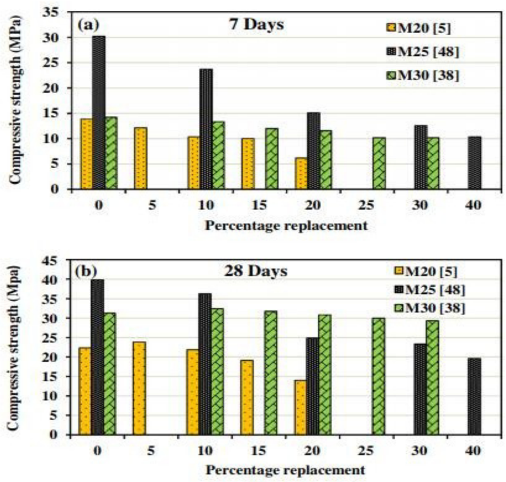


Fig 1. Compressive strength of bagasse ash concrete at (a) 7 days and (b) 28 days of curing.

Groundnut shell

Sada et al. (2013) performed an experiment using groundnut shells as a fine aggregate replacement having a mix ratio of 1:2:3, in which they observed that the compressive strength increased at 5% replacement than the control concrete. However, it decreased by further increment of replacement, which behaved like a lightweight concrete. They also reported that groundnut shell concrete could not be used in important structural members, which are exposed to water, since moisture affects the weight and strength (Sada et al., 2013).

Oyster shell

Yang et al. (2010) tested the compressive strength of oyster shell concrete over a long period of 1 year based on American Society for Testing and Materials (1979). They reported that oyster shell substitution as a fine aggregate showed a drastic increase of compressive strength from 7 days to 28 days curing period and after 28 days, effect was apparent. The compressive strength variance was not proportional to the substitution ratio, which is clear from Fig. 13. Yang et al. (2005) tested the compressive strength using oyster shell as fine aggregate with and without admixture. They reportedthe compressive strength of concrete increased at oyster shell substitution of 5%, but the substitution ratio can be increased up to 10% using admixture in the concrete mix. Kuo et al. Kuo et al. (2013) also examined the same result regarding the oyster shell concrete and the compressive strength decreased due to the porous structure and the absorption rate of oyster shell sand. From Fig. 13 it can be observed that in the mix 1:1.85:2.62 (Yang et al., 2010) the strength increased marginally at 20% replacement of oyster shell than the control concrete, but in the case of controlled low strength concrete (mix 1:6.4:2 Kuo et al., 2013) the strength decreased at all replacement levels than the control concrete.

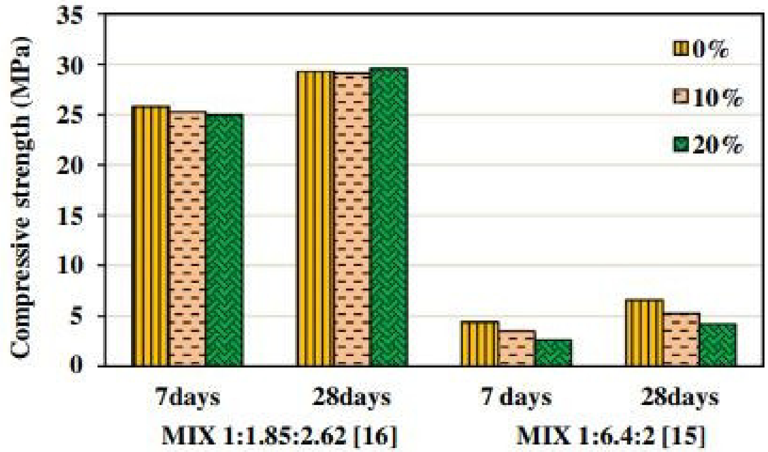


Fig 2 .. Compressive strength of oyster shell concrete Sawdust ash

Mageswari and Vidivelli (2009) have cast the concrete using sawdust ash as fine aggregate in both cube and cylinder. They followed the procedure of compressive strength test as per IS 516: 1959 (Indian Standard, 1959). It has been seen that the strength of concrete containing 5%, 10% and 15% mix ratio of sawdust ash was higher than that of control concrete. However, concrete containing 20%–30% of sawdust ash displayed a reduction in compressive strength than that of plain concrete.

Wild giant reed

Ismail and Jaeel (2014) added giant reed ash and giant reed fibre in concrete as fine aggregate to check the compressive strength of concrete. Casting, compaction and curing were accomplished according to BS 1881 (British Standard Institute, 1983). They reported that in earlier stages of the replacement, compressive strength increased and at higher percentages, it decreased in comparison to the strength of control concrete. However, for all cases the compressive strength was higher than the minimum requirement. Fig. 14 represents comparison of the strength of giant reed ash and giant reed fibres, which confirms that at 7.5% of replacement, giant reed ash concrete provides optimal strength. The cause of such behaviour of giant reed ash concrete is due to the content of silica; giant reed ash may have pozzolanic activity. However, silica with an alumina content of their structure may form additional calcium silicate hydrate (C-S-H) by reacting with calcium hydroxide occurring because of cement hydration, which increases the strength of concrete (Ismail and Jaeel, 2014).

Rice husk ash

Iam and Makul (2013) have cast the self-compacting concrete samples using rice husk ash (RHA), limestone (LS) and a mixture of RHA and LS in cylinder of 150 mm diameter and 300 mm length. Samples were tested after aging for 1, 7, 28 and 91 days in accordance with American Society for Testing and Materials (1979). Compressive strength value was very low at 100% replacement of rice husk ash and it was maximum at 10% replacement of only limestone. The compressive strength value decreased, when the replacement level increased. They attributed lower compressive strength

due to greater porosity as indicated by the higher water requirement of rice husk ash and limestone. However, they found that rice husk ash was able to fill the micro-voids in improved way within the cement particles (Iam and Makul, 2013).

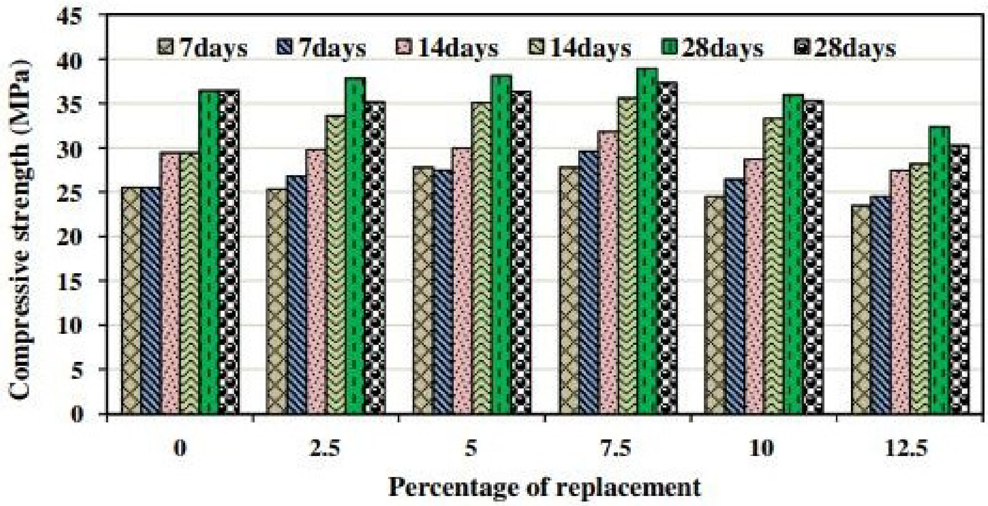


Fig3. Compressive strength of Giant Reed Ash (GRA) and Giant Reed Fibres (GRF) based concrete atmix 1: 1.78: 2.23 (Ismail and Jaeel, 2014).

Cork

Bras et al. Bras et al. (2013) tested the compressive strength of mortar containing cork as fine aggregate and indicated that addition of cork generated a mortar having lower compressive strength. These values may be expected due to higher water binder ratio than the control mortar and an increase of cork as sand replacement. They also explained that when cork replacement is higher than 50%, there was no major difference in compressive strength of mortar that is just 20% of the compressive strength of control mortar (Bras et al., 2013). Compressive strength of lightweight polymer mortar containing waste cork was higher than that of normal mortar as reported by Novoa et al. (2004). Moreira et al. (2014) tested the compressive strength of lightweight screed containing expanded cork according to NP EN 12390-3:2011 (Portuguese Standards, 2011) at the age of 7, 28, 56, and 84 days. They reported that the compressive strength increased, with increase of cement content and it reduced with increase of percentage cork granulates.

Tobacco waste

The 28 day cube compressive strength of tobacco waste lightweight concrete sample was within 0.2–0.6 N/mm2 which varied on the mix ratio. It has been observed that minor amount of organic matter, which is tobacco waste, resulted in a high compressive strength of concrete. The compressive strength of tobacco waste was under 1 N/ mm2 due to which, this lightweight concrete can be suggested to be used as an insulating material for coating and separation material into construction (Ozturk and Bayrakl, 2005)

Gram-Flour, Ghee and Tripala

Patel and Deo (2006) carried out research and experimentation on the electrical resistivity, ultrasonic pulse and carbonation on hardened concrete for 0.4 and 0.45 w/c ratios. Gram-flour, ghee and triphala were used as natural organic materials as admixture on the durability of concrete.

Based on their findings, the addition of gram-flour provided better durability in terms of electrical resistivity, UPV and carbonation for both the w/c ratios over normal concrete. Even under 70% loading, better durability results were noticed for concrete with gram flour. Although for concrete with ghee and triphala poor results were noticed.

Methodology/Design and justification

Identification of materials to be used in the testing of foreign material in cement mortar.

Carrot and potato peeling powder was established to be used in this design project. Upon literature review, it was concluded that these material have not been extensively tested with cement. These materials have a good potential to provide for a solid foundation for any research utilization because they are by-products of daily food items and are readily available in abundance, therefore the supervisor and I have discussed to use them.

Collection of material and Mix Design

The carrot and potato were bought from Victoria Market. These food items were thoroughly washed to ensure that they are free of any foreign chemicals or bacteria of such. Carrot /potato was peeled and the peelings were microwave dried to get the material to a dry state ie to remove all moisture content. A small sample was first dried using the microwave to gather the optimal time required to fully dry the peelings without burning. The sample was carefully observed during the drying process to gather any evidence of burns that have potential and the time was noted.

A fast set cement mortar was used , the particular product was bought from Bunning's warehouse , the specific Trade name of the cement was : Trade Name: Dingo Brickie's Fast Set Mortar, Chemical nature: Blend of Portland Cement, Hydrated Lime & Sand, Product Use: Dingo Brickie's Fast Set Mortar is formulated for brick and block laying application

Photo of fast Set Cement Mortar Used :

Section 3 - Composition/Information on Ingredients

Ingredients	CAS No	Conc,%	TWA (mg/m^3)	STEL (mg/m^3)
Portland cement	65997-15-1	10-30	10	not set
Silica (Crystalline)	14808-60-7	>60	0.1	not set
Calcium hydroxide	1305-62-0	10-30	5	not set
Other non hazardous ingredients	secret	to 100	not set	not set

This is a commercial product whose exact ratio of components may vary slightly. Minor quantities of other non hazardous ingredients are also possible.

Section 9 - Physical and Chemical Properties:

Physical Description & colour:	Grey coloured powder.
Odour:	No odour.
Boiling Point:	Not available.
Freezing/Melting Point:	>1200°C
Volatiles:	No data.
Vapour Pressure:	Nil at normal ambient temperatures.
Vapour Density:	Not applicable.
Specific Gravity:	No data.
Water Solubility:	Forms slurry which sets or hardens on standing.
pH:	About 12
Volatility:	Nil at normal ambient temperatures.
Odour Threshold:	No data.
Evaporation Rate:	Not applicable.
Coeff Oil/water Distribution:	No data
Viscosity:	Not applicable.
Autoignition temp:	Not applicable - does not burn.

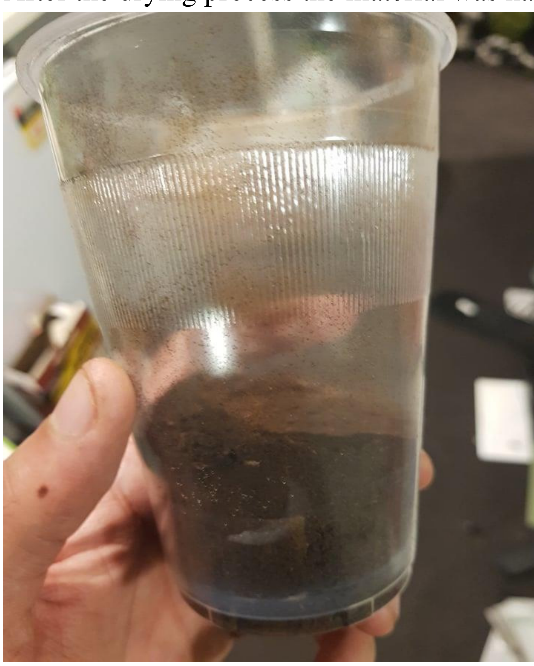
(Dingocement.com.au, 2018)
The potato peeling sample was microwave (1000w) dried for 1hour

30minsPhoto of Potato Peeling before microwave drying :

The carrot peelings was microwave(1000w) dried for 45mins.Photo of carrot peeling before drying :

Photo of the dried material after the established time :

After the drying process the material was hand crushed till it got to the finest particle size.




Mixing and Moulding

A kitchen scale was used to weigh the contents.

100g of weighted cement was replaced with 5%, 10% and 15% carrot and potato peeling powder perweight .

The first specimen was a control sample therefore no foreign material was added into this.

(Control)Following that ;

- Carrot peeling 5%
- Carrot peeling 10%
- Carrot peeling 15%
- Potato peeling 5%
- Potato peeling 10%
- Potato peeling 15%

were replaced per 100g weight of fast set cement mortar. The replacement calculations were done right at the point of before weighing the materials and relevantly the content was mixed and then added with water to a considerable amount for the setting. The dimensional size of the cubes are 30mm by 20mm . A ice cube tray with all equal sized holding capacity was used to set the cement mortar

Initially a 50% , 35% and 25% replacement amount was established and used to make the test specimen, but unfortunately the samples were too brittle therefore the possibility of replacing cement mortar with high percentages of peelings were ruled out. Consequently 5, 10 and 15% wereestablished to be used as replacement.

The samples were then set to be cured with water for a 7day period, and then the testing of thespecimen was carried out on the 7th day at Bundoora Compression test facility.

Photos of the specimen

ControlCarrot Peeling 5%

Testing
Compression test on the cube specimens was done on the 7th day after the

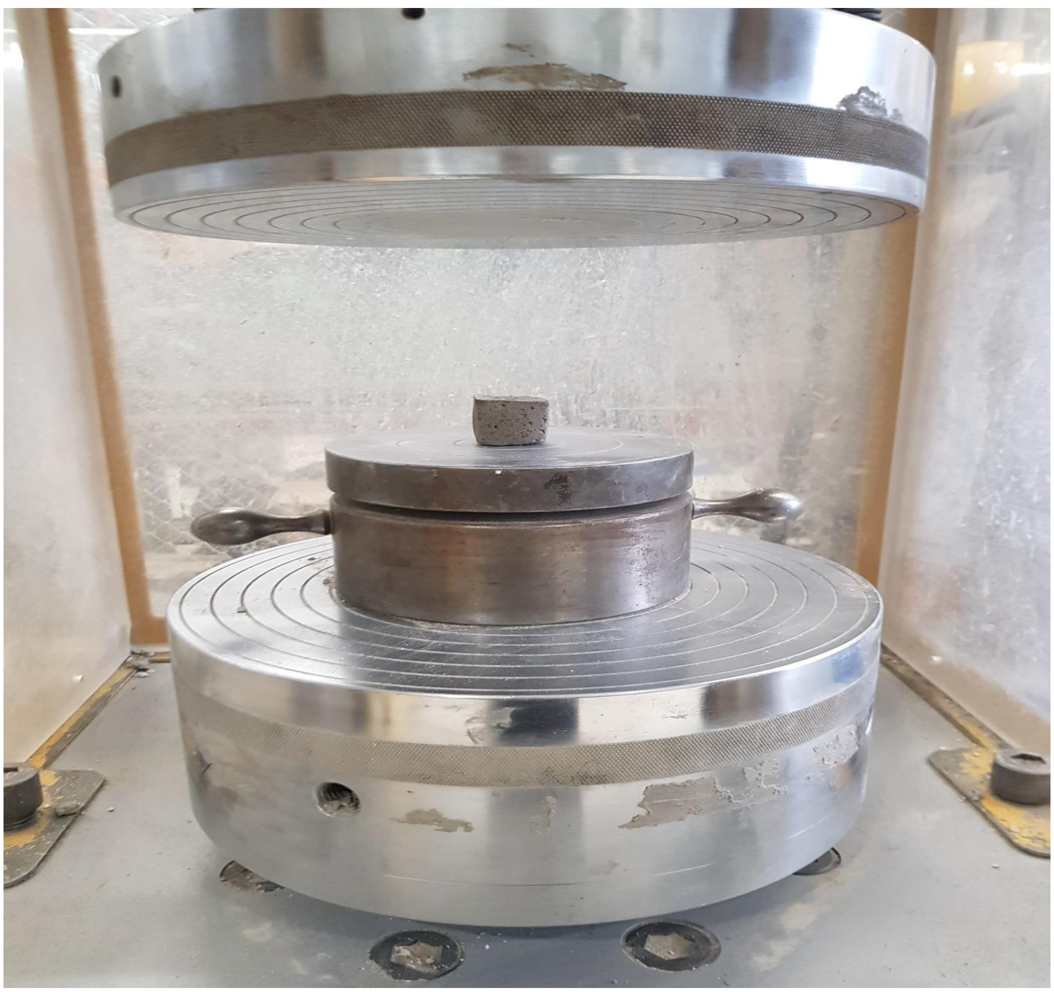
curing. The testing procedure was in accordance with

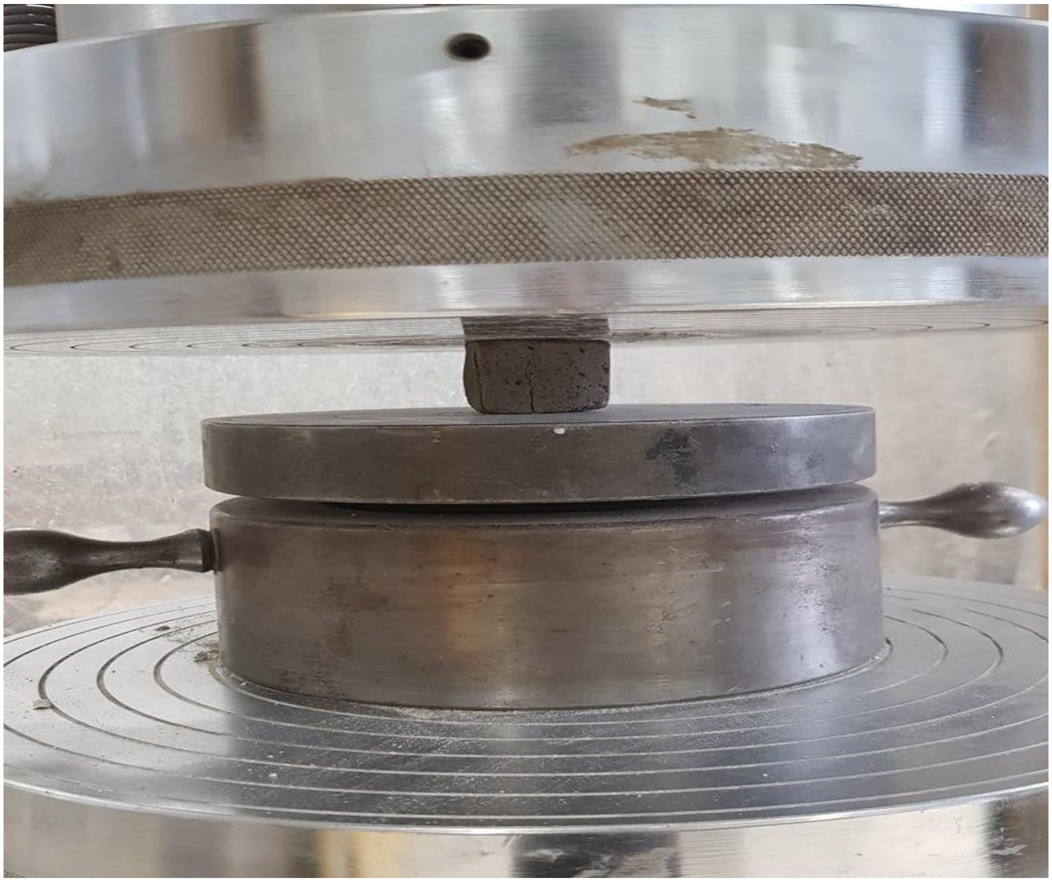
- AS 1012.9.2014 Methods of Testing Concrete
  Method 9: Compressive Strength tests – Concrete, mortar and grout specimens.

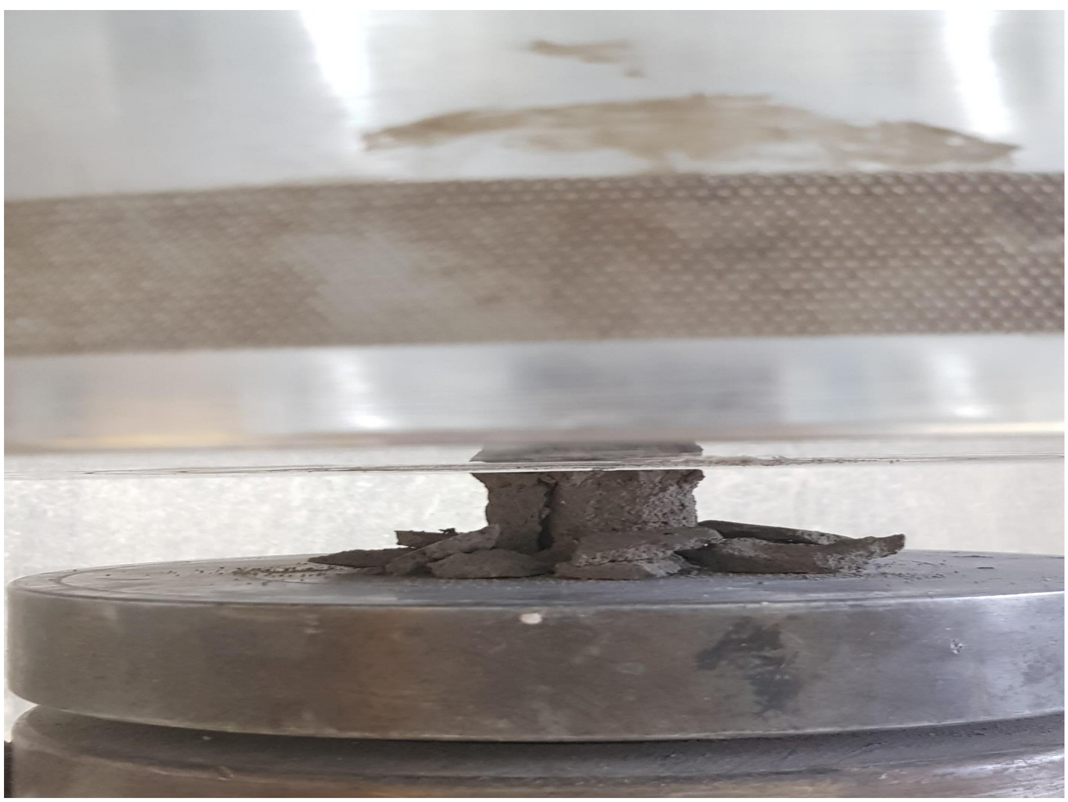
The completion plan has a full reference of The Standard Used for Methods of Testing concrete andCompressive Strength test- concrete, mortar and grout specimens.

The Data Sheets for Control, Carrot peeling powder 5% , Carrot peeling powder 10% , Carrot peeling powder 15% , Potato peeling powder 5% , Potato peeling powder 10% and potato peeling powder 15% has been included in the Appendix section.

Photos of Compression testing :



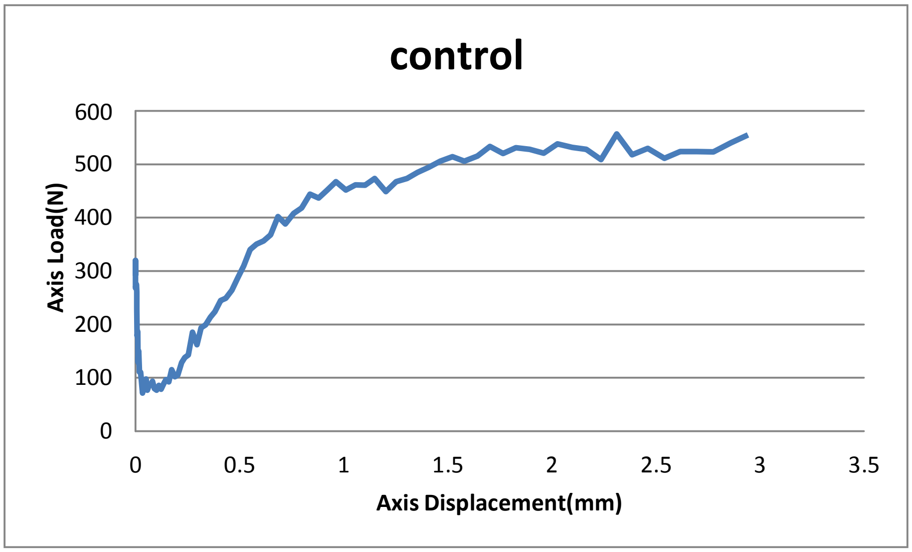




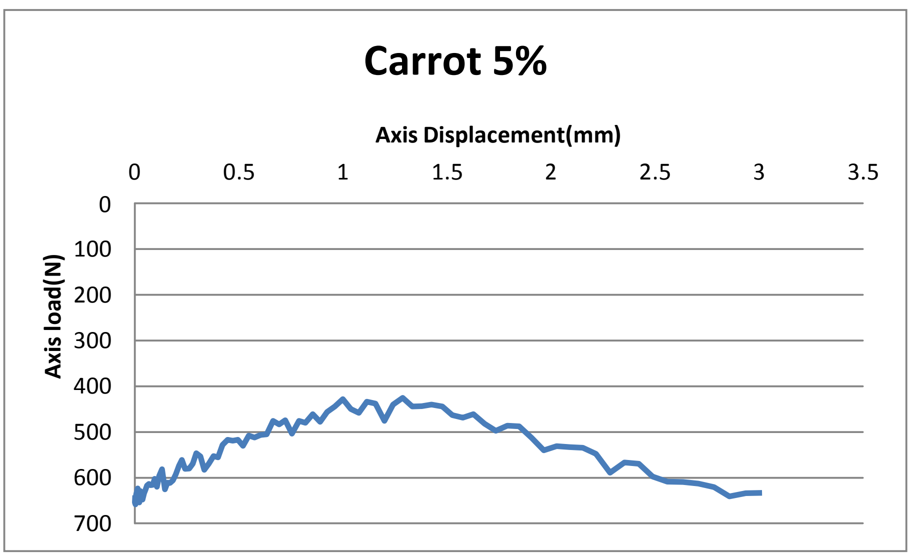
Results and Findings

The nature of the experimentation results were collected in tabular form. The results have been analysed in a graphical method based on the Data Sheets which is attached in the appendix sectionfor reference.

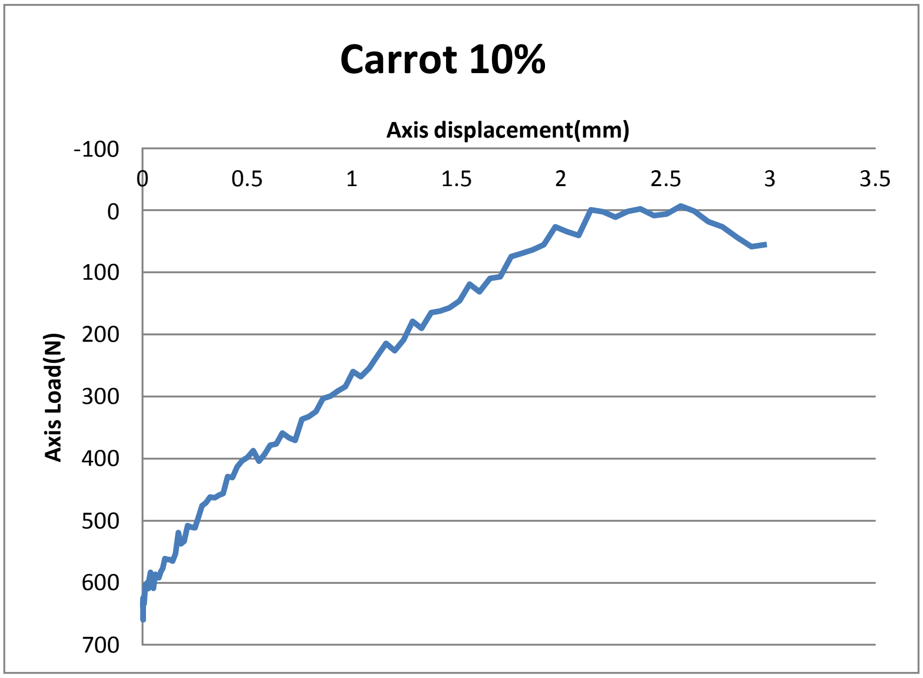
Graph 1 : Control Specimen



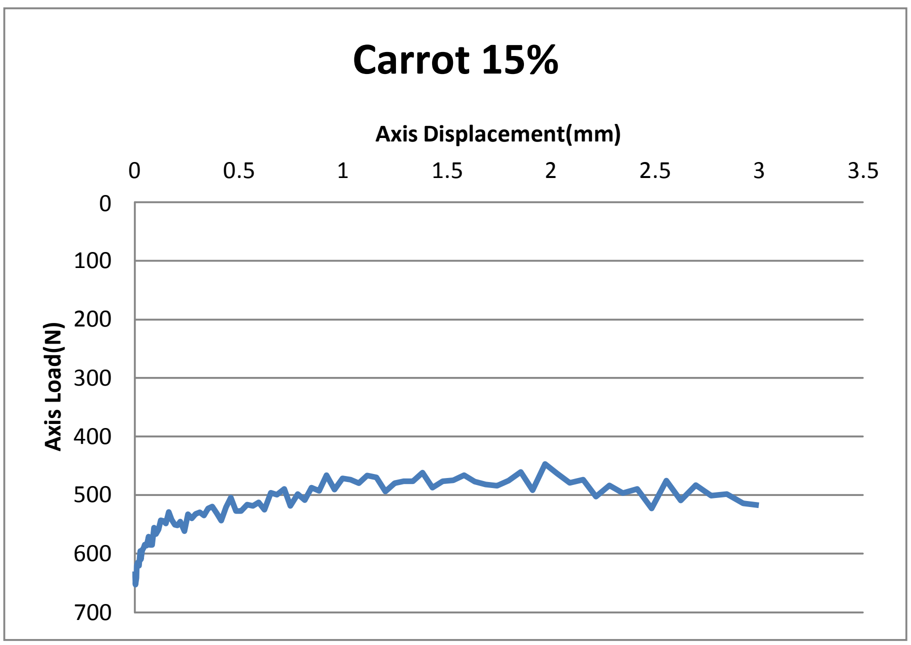
Graph 2 : Carrot 5% Specimen



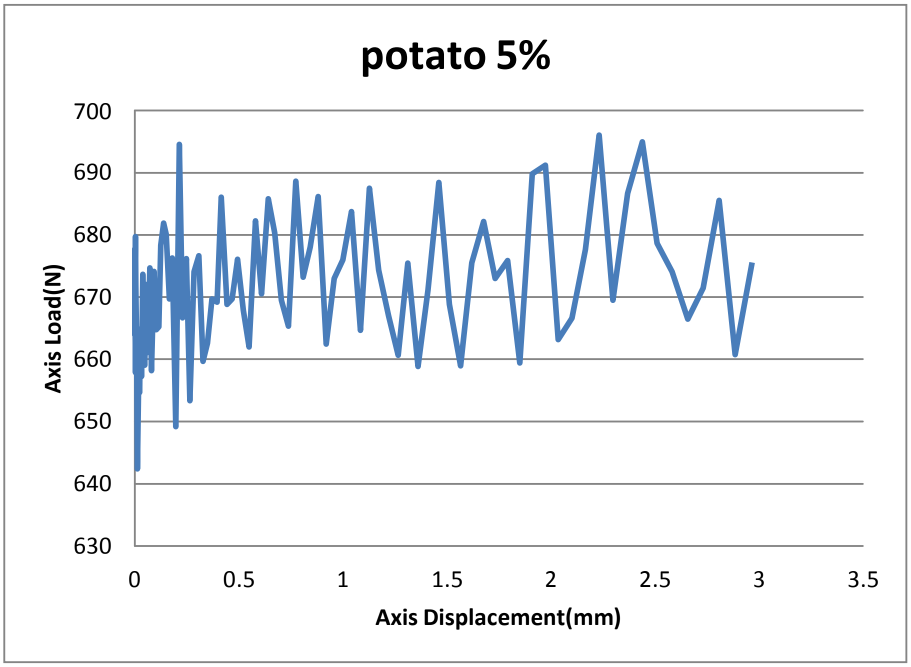
Graph 3 : Carrot 10% Specimen



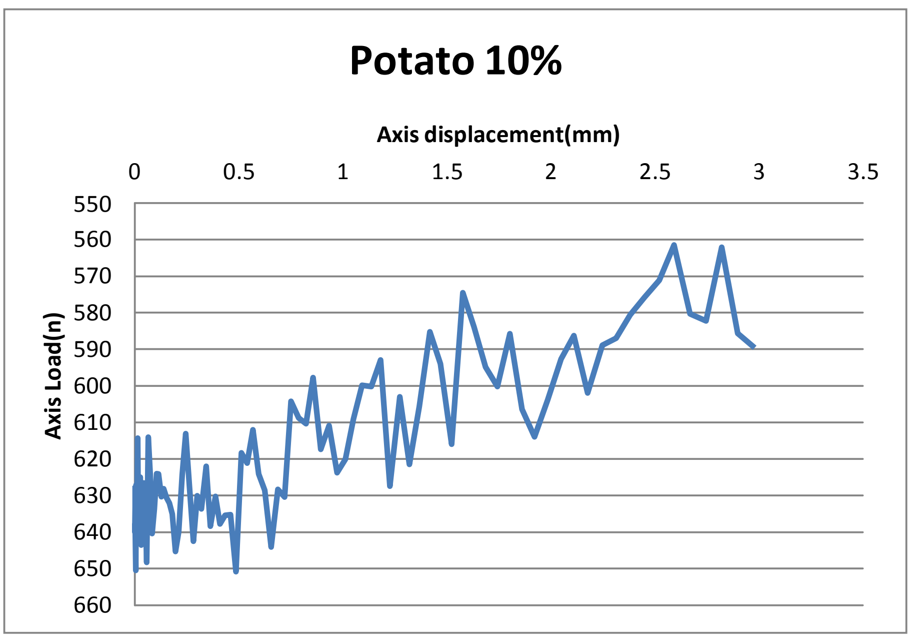
Graph 4 : Carrot 15% Specimen



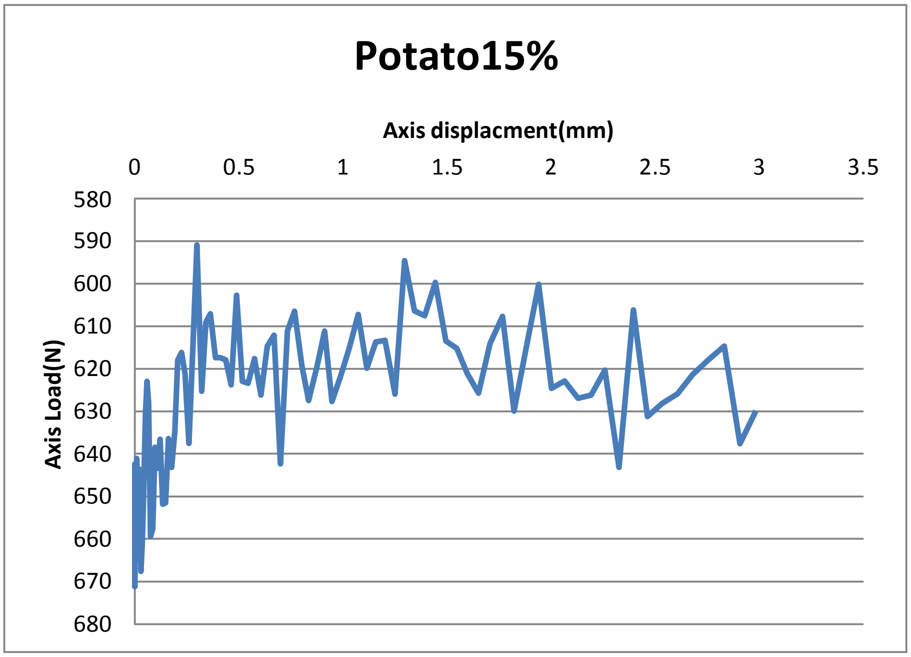
Graph 5 : Potato 5% Specimen



Graph 6 : Potato 10% Specimen



Graph 7 : Potato 15% Specimen



Discussion of results/product(s)

Analysis of Control Specimen with no foreign element:
The control specimen had a maximum load of 550N at 2.5mm displacement. The control specimen will be the set grounds for compression of data with the potato and carrot specimen.

(The 2.5mm displacement range has been set as a comparison median , as this range has themaximum load for the control specimen is within this range)

Analysis of Carrot Specimens:

- Carrot 5% had a maximum strength of roughly 380N
- Carrot 10% had a maximum strength of roughly 700N
- Carrot 15% had a maximum strength of roughly 250N

Based on the interpretation of the graphs, the maximum load displacement on the control specimenhas shown a similar pattern to the specimen with 10% carrot which has a maximum load of 700N at 2.5mm displacement. The 5% carrot displacement for unknown reason has shown an unexpected curve in the graph, maybe due to an unforeseen laboratory or molding/mixing error. The 5% carrot specimen at 2.5mm displacement has a load of roughly 380N, therefore the possibility of comparison with the control specimen has been ruled out. Similarly the 15% carrot specimen at 2.5mm displacement has a maximum load of 250N, therefore due to being below the maximum loadof the control specimen for unknown reason cannot be compared.

Based on these results, the Carrot specimen with 10% has shown favourable strengths, therefore, it can be said that cement with a much as 10% replacement has a possibility but with 15% replacementthe strength of the specimen decreases.

Based on the initial aim of the experiment, it can be said that carrot peelings of certain percentagescan be used with fast set cement mortar.

Analysis of Potato Specimens:
Based on the interpretation of the graphs, potato peelings at 2.5mm displacement has maximumstrength for all 5%,10% and 15% potato peelings.

- Potato 5% had a maximum strength of roughly 950N
- Potato 10% had a maximum strength of roughly 650N
- Potato 15 % had a maximum strength of roughly 650N

Based on the interpretation of the graphs, Potato peeling up to 15% with fast set cement mortar has shown promising results when compared to the control specimen. The control specimen has a max strength of 550N , but the specimen with 5% potato replacement has shown an increased strength of 950N. The specimens with 10% and 15% replacement has strength f roughly 650N again more than the control of 550N .

Therefore it can be said that Potato peelings with up to 15% replacement has potential to be used with fast set cement mortar with results also showing an increased strength of the specimen

Conclusions

In the carrying out of this final year project, the grounds for carrying out this project was to gather ifkitchen waste can be replaced as a material in fast set cement mortar. Initially it was proposed to use eggshell as a replacement material, but upon literature review and feasibility study it was gathered that eggshell powder of up to 5% to 15% can be used with cement. Our virtue was to replace cement with a large percentage of up to 50% eggshell powder, therefore upon research the experiment with large portion of cement replacement was ruled out, as our aim was to replace 50% but literature review and research only confirmed of replacement possibility up to 5%to 15%

The aim of the project was later shifted towards using potato and carrot peeling powder as replacement material with cement, as upon literature review, it was gathered that these materials have never been tested with cement before. The specific aim was replacement of fast set cement mortar with up to 50% carrot and potato peeling powder. A 25%, 35% and 50% sample was moulded and the usual procedure of mixing and testing was carried out. It was gathered that fast set cement mortar with 25% , 35% and 50% potato and carrot peeling powder was extremely brittle , therefore the possibility of carrying out compression testings on these specimens were ruled out.

Later 5%, 10% and 15% potato and carrot peeling powder was moulded with fast set cement mortarinto test specimens for compression testing.

Based on the results gathered from the compression testing it can be concluded that potato peeling powder of up to 10% and carrot peeling powder of up to 15% can be used as a replacement material with fast set cement mortar. It was even more astonishing to gather that fast set mortar specimens with up to 15% potato peeling powder showed an increased strength in compressive strength.

Recommendations/Future works

According to the findings of this project, it would be great if students or researchers in future can do further testing on kitchen waste, as potato and carrot peelings has shown promising results when used as a replacement material with fast set cement mortar. A second authenticated test on carrot and potato peelings will confirm the findings of this project in-case of any unforeseen experimental errors.

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Appendix

Laboratory Test Results per Specimen.

Control

Data Acquisition					Time:	9.113525	s
Axial Count	Time	Axial Displacement	Axial Load				
segments	s	mm	N				
0	0.12207	0.000735	291.5255				
0	0.221924	0.0002	319.4578				
0	0.321777	0.000481	305.0114				
0	0.421631	0.000525	268.2453				
0	0.521484	0.003799	274.9381				
0	0.621338	0.005349	260.9609				

0	0.721191	0.005437	229.732				
0	0.821045	0.007955	178.0769				
0	0.920898	0.009815	186.5317				
0	1.020752	0.011364	128.7048				
0	1.120606	0.014723	149.7743				
0	1.220459	0.017589	116.8934				
0	1.320313	0.019339	110.656				
0	1.420166	0.024597	110.3855				
0	1.52002	0.027568	97.9553				
0	1.619873	0.032677	71.4967				
0	1.719727	0.037984	79.84294				
0	1.81958	0.043737	79.22622				
0	1.919434	0.050557	97.79958				
0	2.019287	0.056088	76.37567				
0	2.119141	0.064371	85.21569				
0	2.218994	0.073407	87.3732				
0	2.318848	0.080928	93.04355				
0	2.418701	0.091241	79.77737				
0	2.518555	0.101825	76.34904				
0	2.618408	0.11137	85.80987				
0	2.718262	0.122634	78.81848				
0	2.818115	0.134607	88.45348				
0	2.917969	0.14585	96.51082				
0	3.017822	0.159536	92.27214				
0	3.117676	0.173829	115.0678				
0	3.217529	0.189035	101.8488				
0	3.317383	0.202901	105.275				
0	3.417236	0.220917	128.0779				
0	3.51709	0.236754	137.9116				
0	3.616943	0.254707	143.0324				
0	3.716797	0.273058	185.1093				
0	3.81665	0.295493	162.0385				
0	3.916504	0.31499	193.5605				
0	4.016357	0.336924	199.4947				
0	4.116211	0.360424	213.1911				
0	4.216065	0.38211	223.3568				
0	4.315918	0.40876	245.1905				
0	4.415772	0.433665	249.1064				
0	4.515625	0.462104	264.1126				
0	4.615479	0.491666	288.0035				
0	4.715332	0.519301	309.3618				
0	4.815186	0.551349	340.0642				
0	4.915039	0.581094	350.1766				
0	5.014893	0.615093	356.4386				
0	5.114746	0.649339	367.7624				

0	5.2146	0.684615	401.6017				
0	5.314453	0.719983	387.9892				
0	5.414307	0.759209	407.8416				
0	5.51416	0.798014	418.3331				
0	5.614014	0.838079	444.0315				
0	5.713867	0.878952	436.7323				
0	5.813721	0.920456	451.3262				
0	5.913574	0.962933	467.0331				
0	6.013428	1.010572	452.052				
0	6.113281	1.056536	461.6107				
0	6.213135	1.103039	460.9611				
0	6.312988	1.150103	473.3591				
0	6.412842	1.202769	448.3614				
0	6.512695	1.251694	467.2544				
0	6.612549	1.304009	473.5456				
0	6.712402	1.355423	484.8484				
0	6.812256	1.408651	493.9834				
0	6.912109	1.465478	505.8502				
0	7.011963	1.523221	514.1473				
0	7.111816	1.580991	505.4814				
0	7.21167	1.642509	515.0119				
0	7.311523	1.702746	533.1079				
0	7.411377	1.764845	519.9114				
0	7.511231	1.82799	530.9442				
0	7.611084	1.893498	527.2531				
0	7.710938	1.960921	520.819				
0	7.810791	2.027465	537.9704				
0	7.910645	2.097581	531.3724				
0	8.010498	2.166423	528.0215				
0	8.110352	2.23756	508.8621				
0	8.210205	2.311971	556.9782				
0	8.310059	2.385215	518.1262				
0	8.409912	2.461643	529.909				
0	8.509766	2.539861	510.9033				
0	8.609619	2.617875	523.3351				
0	8.709473	2.696448	523.7434				
0	8.809326	2.776718	523.1937				
0	8.90918	2.858136	539.8186				
0	9.009033	2.942562	554.5297				

Carrot 5%

Data Acquisition					Time:	9.222412	s
Axial Count	Time	Axial Displacement	Axial Load				
segments	s	mm	N				

0	0.121582	0.002201	638.9484				
0	0.221436	0.00038	653.8455				
0	0.321289	0.002401	658.4991				
0	0.421143	0.005305	636.4933				
0	0.520996	0.007739	634.0817				
0	0.62085	0.012822	623.1001				
0	0.720703	0.016093	640.944				
0	0.820557	0.020947	654.0811				
0	0.92041	0.025502	628.8375				
0	1.020264	0.030245	632.3499				
0	1.120117	0.036154	647.8131				
0	1.219971	0.043288	633.5716				
0	1.319824	0.04985	626.5202				
0	1.419678	0.05775	617.4262				
0	1.519531	0.065982	614.1187				
0	1.619385	0.075572	616.4652				
0	1.719238	0.08524	615.7353				
0	1.819092	0.095938	602.2606				
0	1.918945	0.10523	619.6144				
0	2.018799	0.117235	596.3587				
0	2.118652	0.130242	581.5087				
0	2.218506	0.142671	625.1224				
0	2.318359	0.155885	610.2662				
0	2.418213	0.16861	611.3685				
0	2.518066	0.181717	606.2703				
0	2.61792	0.196057	592.0596				
0	2.717773	0.210835	573.642				
0	2.817627	0.226288	561.306				
0	2.917481	0.242217	580.8531				
0	3.017334	0.260203	579.6191				
0	3.117188	0.278225	568.931				
0	3.217041	0.29565	546.3413				
0	3.316895	0.315668	553.3142				
0	3.416748	0.334829	583.1848				
0	3.516602	0.354833	569.1134				
0	3.616455	0.376802	552.5418				
0	3.716309	0.398663	555.5091				
0	3.816162	0.421133	527.8268				
0	3.916016	0.446036	517.0055				
0	4.015869	0.470421	518.9545				
0	4.115723	0.494142	517.0629				
0	4.215576	0.519339	530.6369				
0	4.31543	0.546101	508.1859				
0	4.415283	0.576203	511.6819				
0	4.515137	0.603842	506.303				

0	4.61499	0.633421	505.2437				
0	4.714844	0.663302	475.3711				
0	4.814697	0.692841	483.2809				
0	4.914551	0.722937	474.2708				
0	5.014404	0.754808	504.0897				
0	5.114258	0.787581	475.6805				
0	5.214111	0.820381	479.7911				
0	5.313965	0.854574	461.0165				
0	5.413818	0.889107	477.7581				
0	5.513672	0.924028	456.0904				
0	5.613525	0.959654	444.0848				
0	5.713379	0.998602	427.8144				
0	5.813232	1.037713	449.937				
0	5.913086	1.076574	458.0845				
0	6.01294	1.115591	433.3577				
0	6.112793	1.157132	438.3596				
0	6.212647	1.199383	475.3773				
0	6.3125	1.240935	439.9045				
0	6.412354	1.287032	425.0479				
0	6.512207	1.333159	444.0028				
0	6.612061	1.379184	443.3206				
0	6.711914	1.425924	440.2118				
0	6.811768	1.477227	444.179				
0	6.911621	1.525879	462.8795				
0	7.011475	1.575748	468.4858				
0	7.111328	1.626808	461.1435				
0	7.211182	1.680476	481.5532				
0	7.311035	1.734886	497.4466				
0	7.410889	1.790245	486.1576				
0	7.510742	1.846778	487.5099				
0	7.610596	1.907183	512.817				
0	7.710449	1.965687	540.2698				
0	7.810303	2.027414	531.2413				
0	7.910156	2.089604	532.7944				
0	8.01001	2.152555	534.3372				
0	8.109863	2.216844	547.46				
0	8.209717	2.283695	588.7808				
0	8.30957	2.352894	566.2817				
0	8.409424	2.42153	569.6215				
0	8.509277	2.488638	597.3017				
0	8.609131	2.559792	608.6353				
0	8.708984	2.63383	609.3975				
0	8.808838	2.708048	612.7603				
0	8.908691	2.783028	620.6306				
0	9.008545	2.857689	640.5466				

0	9.108398	2.936374	634.5551				
0	9.208252	3.01498	633.0798				

Carrot 10%

Data Acquisition					Time:	10.06543	s
Axial Count	Time	Axial Displacement	Axial Load				
segments	s	mm	N				
0	0.122314	0.000587	629.6207				
0	0.222168	0.000748	637.7457				
0	0.322021	0.002543	629.0998				
0	0.421875	0.002004	637.9587				
0	0.521729	0.00162	659.8842				
0	0.621582	0.00276	626.8399				
0	0.721436	0.000927	625.2351				
0	0.821289	0.000966	625.108				
0	0.921143	0.004094	625.5383				
0	1.020996	0.005604	621.9424				
0	1.12085	0.007543	633.6986				
0	1.220703	0.011962	602.7708				
0	1.320557	0.016551	609.9794				
0	1.42041	0.020809	600.4632				
0	1.520264	0.026487	609.881				
0	1.620117	0.031652	594.1638				
0	1.719971	0.038305	582.7668				
0	1.819824	0.043625	599.1909				
0	1.919678	0.051055	609.0861				
0	2.019531	0.059941	586.1582				
0	2.119385	0.067534	589.8298				
0	2.219238	0.076911	591.7399				
0	2.319092	0.086477	581.8775				
0	2.418945	0.095931	576.8674				
0	2.518799	0.106641	561.3674				
0	2.618652	0.118531	562.4242				
0	2.718506	0.130173	562.585				
0	2.818359	0.142631	565.181				
0	2.918213	0.156271	553.6339				
0	3.018066	0.170228	518.7783				
0	3.11792	0.184032	537.532				
0	3.217773	0.198476	532.9276				
0	3.317627	0.214767	507.8971				
0	3.417481	0.232519	510.2456				
0	3.517334	0.249189	511.3951				
0	3.617188	0.266135	494.008				
0	3.717041	0.284091	475.9551				

0	3.816895	0.3034	471.449				
0	3.916748	0.322573	461.8283				
0	4.016602	0.343698	462.7667				
0	4.116455	0.364448	458.9799				
0	4.216309	0.384765	456.3137				
0	4.316162	0.406173	428.8025				
0	4.416016	0.429658	430.081				
0	4.515869	0.452924	412.9992				
0	4.615723	0.477241	403.2065				
0	4.715576	0.501638	398.2865				
0	4.81543	0.528069	387.0672				
0	4.915283	0.556137	403.9461				
0	5.015137	0.58123	393.3989				
0	5.11499	0.609773	378.4321				
0	5.214844	0.638906	376.5471				
0	5.314697	0.667375	358.3625				
0	5.414551	0.699505	366.5187				
0	5.514404	0.727925	370.4875				
0	5.614258	0.760956	336.7527				
0	5.714111	0.793524	332.9576				
0	5.813965	0.828346	324.0745				
0	5.913818	0.862281	303.1977				
0	6.013672	0.896248	299.3329				
0	6.113525	0.932413	291.0584				
0	6.213379	0.96881	283.9215				
0	6.313232	1.005344	259.7085				
0	6.413086	1.043456	267.7126				
0	6.51294	1.082148	254.4956				
0	6.612793	1.121811	234.0885				
0	6.712647	1.162154	214.2975				
0	6.8125	1.204111	225.9123				
0	6.912354	1.247656	208.5396				
0	7.012207	1.290869	178.5256				
0	7.112061	1.334062	190.0891				
0	7.211914	1.377349	164.4194				
0	7.311768	1.422064	162.1553				
0	7.411621	1.467485	157.1201				
0	7.511475	1.515131	145.4034				
0	7.611328	1.562607	118.8834				
0	7.711182	1.609707	130.8792				
0	7.811035	1.660356	109.5147				
0	7.910889	1.710667	106.6253				
0	8.010742	1.761335	74.31857				
0	8.110596	1.812674	69.30232				
0	8.210449	1.863746	63.69189				

0	8.310303	1.916713	55.15255				
0	8.410156	1.971393	26.38893				
0	8.51001	2.028182	34.68804				
0	8.609863	2.083231	40.4255				
0	8.709717	2.14308	-0.81342				
0	8.80957	2.199715	1.95927				
0	8.909424	2.258946	11.4365				
0	9.009277	2.318265	1.39121				
0	9.109131	2.380232	-2.47508				
0	9.208984	2.442988	8.16593				
0	9.308838	2.50451	5.90547				
0	9.408691	2.571117	-7.02827				
0	9.508545	2.635633	0.840053				
0	9.608398	2.703536	17.91567				
0	9.708252	2.771408	26.74954				
0	9.808106	2.841732	43.9235				
0	9.907959	2.910439	58.25306				
0	10.00781	2.982779	55.12387				

Carrot 15%

Data Acquisition					Time:	8.776611	s
Axial Count	Time	Axial Displacement	Axial Load				
segments	s	mm	N				
0	0.122314	0.001231	495.6128				
0	0.222168	0.000379	518.6139				
0	0.322021	0.000295	494.2641				
0	0.421875	0.002324	510.7988				
0	0.521729	0.002924	510.092				
0	0.621582	0.005851	478.1561				
0	0.721436	0.007358	493.0389				
0	0.821289	0.008747	496.4877				
0	0.921143	0.012171	498.7231				
0	1.020996	0.017435	478.7626				
0	1.12085	0.021861	489.5819				
0	1.220703	0.026305	469.271				
0	1.320557	0.030345	468.3731				
0	1.42041	0.036199	475.2974				
0	1.520264	0.042685	503.6246				
0	1.620117	0.050487	722.7744				
0	1.719971	0.062181	467.9531				
0	1.819824	0.079664	368.1046				
0	1.919678	0.097893	370.1719				
0	2.019531	0.116448	769.1571				
0	2.119385	0.056836	1263.364				

0	2.219238	0.127235	1095.908				
0	2.319092	0.107281	3269.58				
0	2.418945	0.146775	243.6087				
0	2.518799	0.164739	1029.237				
0	2.618652	0.160256	1063.521				
0	2.718506	0.19192	703.5167				
0	2.818359	0.230711	137.9362				
0	2.918213	0.225935	1183.076				
0	3.018066	0.295459	192.5929				
0	3.11792	0.284477	921.134				
0	3.217773	0.305583	493.2171				
0	3.317627	0.32865	453.4923				
0	3.417481	0.352139	456.8305				
0	3.517334	0.376017	514.4075				
0	3.617188	0.402363	420.5848				
0	3.717041	0.42809	511.9523				
0	3.816895	0.452399	449.2383				
0	3.916748	0.468656	690.857				
0	4.016602	0.530452	850.1823				
0	4.116455	0.510479	1815.582				
0	4.216309	0.543517	2366.837				
0	4.316162	0.617178	778.2122				
0	4.416016	0.623786	1905.884				
0	4.515869	0.662383	1012.524				
0	4.615723	0.63492	824.3281				
0	4.715576	0.711499	838.7217				
0	4.81543	0.75994	468.4345				
0	4.915283	0.808761	713.0616				
0	5.015137	0.844714	465.3141				
0	5.11499	0.883049	465.4862				
0	5.214844	0.924524	471.1663				
0	5.314697	0.967373	509.6187				
0	5.414551	1.003697	526.0914				
0	5.514404	1.044914	551.7632				
0	5.614258	1.080296	717.0841				
0	5.714111	1.140911	478.2545				
0	5.813965	1.185919	682.4391				
0	5.913818	1.237484	465.1891				
0	6.013672	1.288034	244.6475				
0	6.113525	1.342233	388.7494				
0	6.213379	1.382618	472.1436				
0	6.313232	1.43414	525.6898				
0	6.413086	1.460763	200.7547				
0	6.51294	1.499383	814.0887				
0	6.612793	1.600147	550.6425				

0	6.712647	1.652536	602.2934				
0	6.8125	1.710712	494.3953				
0	6.912354	1.766097	510.5038				
0	7.012207	1.821611	509.7191				
0	7.112061	1.879484	519.4176				
0	7.211914	1.938787	509.6453				
0	7.311768	1.999575	531.5568				
0	7.411621	2.061943	509.1597				
0	7.511475	2.123998	514.9669				
0	7.611328	2.187213	525.3722				
0	7.711182	2.252819	545.5012				
0	7.811035	2.319918	529.8127				
0	7.910889	2.385887	539.8309				
0	8.010742	2.455327	557.3941				
0	8.110596	2.526999	556.2365				
0	8.210449	2.599965	555.087				
0	8.310303	2.670787	571.5316				
0	8.410156	2.744403	552.593				
0	8.51001	2.820247	571.3738				
0	8.609863	2.896875	580.1354				
0	8.709717	2.976139	599.6416				

Potato 5%

Data Acquisition					Time:	9.087891	s
Axial Count	Time	Axial Displacement	Axial Load				
segments	s	mm	N				
0	0.12207	0.000602	675.1998				
0	0.221924	0.002405	657.8332				
0	0.321777	0.00047	677.7404				
0	0.421631	0.000387	663.9399				
0	0.521484	0.001485	675.9128				
0	0.621338	0.0025	679.6833				
0	0.721191	0.005007	671.8616				
0	0.821045	0.009108	660.169				
0	0.920898	0.01223	642.3762				
0	1.020752	0.017151	656.8662				
0	1.120606	0.02119	654.6569				
0	1.220459	0.026331	664.8518				
0	1.320313	0.032423	657.2697				
0	1.420166	0.037646	673.6364				
0	1.52002	0.045761	659.0523				
0	1.619873	0.053438	672.0009				
0	1.719727	0.061419	661.1238				

0	1.81958	0.070846	674.6855				
0	1.919434	0.079539	658.1589				
0	2.019287	0.091634	674.1446				
0	2.119141	0.10251	664.7595				
0	2.218994	0.113867	665.1918				
0	2.318848	0.124949	678.3556				
0	2.418701	0.137097	681.8695				
0	2.518555	0.15049	680.0541				
0	2.618408	0.165174	669.6652				
0	2.718262	0.180088	676.2652				
0	2.818115	0.196066	649.2042				
0	2.917969	0.212898	694.5456				
0	3.017822	0.22921	666.6343				
0	3.117676	0.247153	676.1545				
0	3.217529	0.265038	653.3538				
0	3.317383	0.283762	674.0626				
0	3.417236	0.30634	676.6381				
0	3.51709	0.326411	659.6813				
0	3.616943	0.347898	662.6036				
0	3.716797	0.369718	669.6611				
0	3.81665	0.394469	669.1406				
0	3.916504	0.41555	686.0395				
0	4.016357	0.443194	668.7943				
0	4.116211	0.466932	669.6877				
0	4.216065	0.492936	676.0685				
0	4.315918	0.520582	667.9046				
0	4.415772	0.548005	661.9295				
0	4.515625	0.57971	682.2628				
0	4.615479	0.608835	670.499				
0	4.715332	0.639927	685.767				
0	4.815186	0.671529	680.3082				
0	4.915039	0.703976	669.491				
0	5.014893	0.737217	665.2922				
0	5.114746	0.77232	688.6155				
0	5.2146	0.807788	673.1688				
0	5.314453	0.843399	677.9883				
0	5.414307	0.881374	686.144				
0	5.51416	0.919585	662.4356				
0	5.614014	0.957844	672.9557				
0	5.713867	0.99938	675.9763				
0	5.813721	1.040823	683.7263				
0	5.913574	1.084034	664.6366				
0	6.013428	1.12716	687.4594				
0	6.113281	1.171321	674.3433				
0	6.213135	1.218948	666.9867				

0	6.312988	1.265292	660.632				
0	6.412842	1.311931	675.4579				
0	6.512695	1.360629	658.8392				
0	6.612549	1.408983	671.0707				
0	6.712402	1.460669	688.3779				
0	6.812256	1.512179	668.821				
0	6.912109	1.565571	658.9601				
0	7.011963	1.61911	675.4846				
0	7.111816	1.676489	682.1625				
0	7.21167	1.732774	672.9946				
0	7.311523	1.791083	675.8677				
0	7.411377	1.850031	659.3699				
0	7.511231	1.90987	689.7854				
0	7.611084	1.973025	691.2136				
0	7.710938	2.035138	663.1788				
0	7.810791	2.10143	666.5831				
0	7.910645	2.165279	677.6195				
0	8.010498	2.231196	696.0269				
0	8.110352	2.297597	669.4766				
0	8.210205	2.367905	686.646				
0	8.310059	2.439302	694.9164				
0	8.409912	2.509872	678.6014				
0	8.509766	2.582181	674.0299				
0	8.609619	2.657075	666.4294				
0	8.709473	2.731935	671.4293				
0	8.809326	2.808072	685.5314				
0	8.90918	2.885157	660.7673				
0	9.009033	2.966757	675.5256				

Potato 10%

Data Acquisition					Time:	9.270264	s
Axial Count	Time	Axial Displacement	Axial Load				
segments	s	mm	N				
0	0.121338	0.002082	627.35				
0	0.221191	0.001075	633.0839				
0	0.321045	0.000617	639.9298				
0	0.420898	0.001635	637.7088				
0	0.520752	0.004318	650.4786				
0	0.620605	0.006033	627.139				
0	0.720459	0.005844	627.3623				
0	0.820313	0.010106	630.9792				
0	0.920166	0.013221	614.2437				

0	1.02002	0.016057	625.6489				
0	1.119873	0.020807	628.3397				
0	1.219727	0.026034	624.9236				
0	1.31958	0.030344	643.5487				
0	1.419434	0.037625	632.1798				
0	1.519287	0.043444	626.5161				
0	1.619141	0.049304	629.7273				
0	1.718994	0.056996	648.2351				
0	1.818848	0.06579	614.004				
0	1.918701	0.073979	624.1328				
0	2.018555	0.084094	640.3396				
0	2.118408	0.093893	633.5982				
0	2.218262	0.104534	624.0549				
0	2.318115	0.114755	624.1143				
0	2.417969	0.127599	630.3174				
0	2.517822	0.139035	628.184				
0	2.617676	0.152423	630.5407				
0	2.717529	0.165933	632.0303				
0	2.817383	0.179447	635.0734				
0	2.917236	0.195409	645.3354				
0	3.01709	0.211097	639.9523				
0	3.116943	0.226746	624.397				
0	3.216797	0.244729	613.0799				
0	3.31665	0.263223	627.936				
0	3.416504	0.281406	642.5365				
0	3.516357	0.300522	630.0776				
0	3.616211	0.320251	633.6392				
0	3.716065	0.342291	621.9793				
0	3.815918	0.363403	638.3624				
0	3.915772	0.387278	630.2313				
0	4.015625	0.409688	637.7252				
0	4.115479	0.43369	635.4525				
0	4.215332	0.460541	635.2435				
0	4.315186	0.486278	650.8208				
0	4.415039	0.512644	618.2847				
0	4.514893	0.538838	621.0691				
0	4.614746	0.567401	612.0452				
0	4.7146	0.596372	624.1675				
0	4.814453	0.62416	628.6285				
0	4.914307	0.655054	644.0999				
0	5.01416	0.686518	628.3765				
0	5.114014	0.719856	630.3706				
0	5.213867	0.750422	604.201				
0	5.313721	0.786301	608.8361				
0	5.413574	0.822586	610.3584				

0	5.513428	0.857388	597.6685				
0	5.613281	0.893876	617.3176				
0	5.713135	0.933573	610.8666				
0	5.812988	0.97192	623.723				
0	5.912842	1.011616	620.1143				
0	6.012695	1.050651	609.1311				
0	6.112549	1.092699	599.8403				
0	6.212402	1.137211	600.1661				
0	6.312256	1.18138	592.9222				
0	6.412109	1.226183	627.4606				
0	6.511963	1.274152	602.9511				
0	6.611816	1.320894	621.5142				
0	6.71167	1.368316	605.5798				
0	6.811523	1.418989	585.1497				
0	6.911377	1.469582	594.0081				
0	7.011231	1.523234	615.9504				
0	7.111084	1.575527	574.4943				
0	7.210938	1.631672	583.8342				
0	7.310791	1.686421	594.8195				
0	7.410645	1.743917	600.1826				
0	7.510498	1.802668	585.7628				
0	7.610352	1.861504	606.4076				
0	7.710205	1.922142	613.9527				
0	7.810059	1.984383	603.9059				
0	7.909912	2.048479	592.5883				
0	8.009766	2.111478	586.2362				
0	8.109619	2.176998	601.8872				
0	8.209473	2.247448	588.8915				
0	8.309326	2.313135	587.0147				
0	8.40918	2.381356	580.5929				
0	8.509033	2.451443	575.695				
0	8.608887	2.521882	571.1157				
0	8.70874	2.593212	561.4535				
0	8.808594	2.669763	580.2748				
0	8.908447	2.745827	582.2463				
0	9.008301	2.820945	562.0006				
0	9.108154	2.89795	585.6849				
0	9.208008	2.979566	589.5676				

Potato 15%

Data Acquisition					Time:	9.162354	s
Axial Count	Time	Axial Displacement	Axial Load				
segments	s	mm	N				
0	0.122314	0.000565	657.4521				
0	0.222168	0.000355	658.1426				

0	0.322021	0.000275	642.4152				
0	0.421875	0.000165	654.7203				
0	0.521729	3.65E-05	671.1301				
0	0.621582	0.000218	664.153				
0	0.721436	0.003447	645.3948				
0	0.821289	0.005913	665.0751				
0	0.921143	0.009258	641.0916				
0	1.020996	0.013349	651.2203				
0	1.12085	0.018782	656.169				
0	1.220703	0.023199	643.6511				
0	1.320557	0.029003	667.5727				
0	1.42041	0.035261	661.3839				
0	1.520264	0.04215	651.1507				
0	1.620117	0.050734	631.0754				
0	1.719971	0.057702	622.9096				
0	1.819824	0.065982	627.8192				
0	1.919678	0.075659	659.3966				
0	2.019531	0.087325	657.6693				
0	2.119385	0.096354	638.4751				
0	2.219238	0.107615	643.4504				
0	2.319092	0.121907	636.5999				
0	2.418945	0.134999	651.8391				
0	2.518799	0.147975	651.5789				
0	2.618652	0.1621	636.4503				
0	2.718506	0.176514	643.1287				
0	2.818359	0.191775	634.6903				
0	2.918213	0.206941	617.965				
0	3.018066	0.224837	616.2373				
0	3.11792	0.241368	621.2908				
0	3.217773	0.260632	637.5546				
0	3.317627	0.278866	615.68				
0	3.417481	0.298074	590.9061				
0	3.517334	0.320584	625.2944				
0	3.617188	0.340801	609.0471				
0	3.717041	0.363333	607.0884				
0	3.816895	0.387077	617.3544				
0	3.916748	0.411278	617.3893				
0	4.016602	0.436128	617.879				
0	4.116455	0.462972	623.768				
0	4.216309	0.488445	602.6868				
0	4.316162	0.515712	622.9505				
0	4.416016	0.544947	623.4361				
0	4.515869	0.574991	617.629				
0	4.615723	0.605811	626.1719				
0	4.715576	0.63697	614.6637				

0	4.81543	0.668939	612.1046				
0	4.915283	0.700126	642.3557				
0	5.015137	0.732784	611.0653				
0	5.11499	0.767223	606.463				
0	5.214844	0.802943	619.221				
0	5.314697	0.836438	627.4197				
0	5.414551	0.874278	619.5714				
0	5.514404	0.912511	611.1022				
0	5.614258	0.948229	627.6614				
0	5.714111	0.990373	621.4876				
0	5.813965	1.0329	614.8378				
0	5.913818	1.072644	607.2461				
0	6.013672	1.115303	619.8029				
0	6.113525	1.158777	613.6967				
0	6.213379	1.202733	613.3442				
0	6.313232	1.250263	625.9731				
0	6.413086	1.296633	594.5716				
0	6.51294	1.344388	606.4158				
0	6.612793	1.394548	607.4899				
0	6.712647	1.444502	599.6826				
0	6.8125	1.495875	613.4733				
0	6.912354	1.547134	615.2415				
0	7.012207	1.599182	621.1618				
0	7.112061	1.652688	625.7288				
0	7.211914	1.707731	614.0818				
0	7.311768	1.76644	607.6785				
0	7.411621	1.823195	629.9219				
0	7.511475	1.883452	614.2888				
0	7.611328	1.941773	600.16				
0	7.711182	2.003295	624.6204				
0	7.811035	2.066121	622.8604				
0	7.910889	2.130226	626.9608				
0	8.010742	2.193955	626.1863				
0	8.110596	2.259399	620.3356				
0	8.210449	2.327347	643.1246				
0	8.310303	2.395343	606.1802				
0	8.410156	2.464248	631.3029				
0	8.51001	2.53493	628.1552				
0	8.609863	2.607944	625.8892				
0	8.709717	2.680689	621.3503				
0	8.80957	2.755537	617.9732				
0	8.909424	2.834546	614.6944				
0	9.009277	2.908554	637.6679				
0	9.109131	2.985384	629.8912				