links. The strengthening of road link was based on the population benefited by the link, facility index of the villages and the Pavement Condition Index (PCI) of the road. In this study PCI value of each road link was determined based on the comfortable driving speed of the vehicle as per PMGSY-II guidelines and PCI values are indexed on scale from 1 to 5 where '1' shows worst possible condition and '5' shows the best possible condition of the pavement. The comfortable speed of the vehicle was observed from the field surveys by travelling on each road link. The car was used as a design vehicle. Facility index values were obtained from the facilities availability from the village. Further, the link weightage was estimated using the equation 1 given below.

$$W_{ij} = (P_i * P_j)(F_i - F_j) / d^2 \tag{1}$$

where,
W_{ij}- Weightage
P_i and P_j- Population of villages i and j
F_i and F_j – Facility index values of village i and j
d- Distance between village i and j
If F_i - F_j = 0 then take this value as 1

Strengthening or maintenance of Rural Roads

The link weigthtage and PCI value of the links are taken as a measure for strengthening/upgradation of the pavement based on the criteria is given below.

- First strengthening of the through rout based on which link had higher weightage and who's PCI value is < or = 2.
- After this strengthening of those link routes based on which link had higher weightage and who's PCI value is < or =2.

Prioritization of the road links for strengthening or maintenance works were prepared for the study area based on the model was shown in table 1.

Table 1. Priority List for the Maintenance of links

Node i	Node j	Weightage	Priority
23	46	55.67	1
22	9	14.42	2
18	22	12.9	3
1	12	3.44	4
20	26	3.37	5
25	33	2.54	6
30	7	2.12	7
6	32	1.72	8
14	26	1.71	9
1	23	1.53	10

CONCLUSIONS

This study has undertaken an extended attempt to develop Geographic Information System (GIS) based rural road database. The developed Advanced Rural Road Information System (ARRIS) will be useful to policy makers, government departments, Non-Government Organizations, general public for planning, development and management of road facilities in the rural areas. Geesukonda habitation was designed as a rural hub based on the cumulative weightage of rural infrastructures and the number of trough-routes they have. Network analysis was carried out for shortest path analysis, closest facilities to habitations, Vehicle routing problems, Location – Allocation problems. Connectivity analysis was carried out for the study area before and after identification of critical links of the network. GIS based rural road model has been developed for Strengthening of roads based on population benefited and PCI value of the link.

REFERENCES

Anjaneyulu, M. V. L. R., and Keerthi, M. G. (2007). "Rural road network planning using GIS a case study in Palakkad." *Proc., National Conference on Rural Roads,* New Delhi, India, 18-25.

Chandrashekhar, B. P. (2005). "Rural Transportation Planning & Development–A Case Study of PMGSY". *National Rural Roads Development Agency*, Ministry of Rural Development, India, 37–148.

Durai B.K., Rao, A. M.,Jain, P.K., and Sikdar, P.K. (2004). "Geographical Information System for Planning and Management of Rural Roads." *Map India*.

Hema, V., Sailaja, K., Santosh, K. M., Anji, R. (2011). "Mandal Level Information System Using ArcGIS." – A Case Study Of Addanki Mandal,Prakasam District, Andhra Pradesh, India, *Journal of Engineering Research and Studies*, II(IV),199-203.

Kumar,P., Garg,R.D., Durai,B.K., and Subrahmanyam,A.S. (2011). "Upgradation planning of rural roads using GIS and GPS". *Journal of Indian Highways*, India Roads Congress, New Delhi.

Mishra, K. K., and Naresh, T. (2009). "Using Geo-informatics for Development of Rural Roads under Pradhan Mantri Gram Sadak Yojna." *10th ESRI India User Conference*, 28-29 April.

Praveen, K. R., Prince, K. S., Abhishek, K. S., Kshitij, M. (2013). "Network Analysis Using GIS." *International Journal of Emerging Technologies in Computational and Applied Sciences* (IJETCAS), 5(3), 289-292.

Rao A. M., Kanagadurai, B, K., and Jain, P. K. (2007). "GIS based district rural and plan: A case study of Ranchi district." *National conference on rural roads*, New Delhi, India, 40-47.

Singh, A.K., (2010). "GIS Based Rural Road Network Planning for Developing Countries". *Journal of Transportation Engineering*, 1943-5436.0000212.

Influence of an Earth Dam Cut-Off Plastic Concrete Component on Its Physical Properties

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Abstract: Plastic concrete is a suitable material for building earth dam cut off due to low permeability, high deformability and enough strength to withstand applied stresses. Due to the lack of a specified standard for plastic concrete materials, evaluation of the effect of the amount and quality of materials such as concrete aggregates (fine and coarse gravel and sand), cement, water and bentonite on the mechanical properties of plastic concrete is considered to be a serious need. In this study, we have investigated the effect of the ratio of mixing materials (mixture proportions) and cement as well as the materials' quality such as the type of bentonite on compressive strength and modulus of plastic concrete elasticity. The results of this study showed that by decreasing the ratio of term activity, compressive strength will be reduced due to increasing free water in case of the stability of other parameters. However, the effect of aggregates unlike cement has no direct effect on mechanical properties of plastic concrete.

INTRODUCTION

The fine and coarse aggregates generally occupy 60% to 75% of the concrete volume (70% to 85% by mass) and strongly influence the concrete's freshly mixed and hardened properties, mixture proportions, and economy. Fine aggregates generally consist of natural sand or crushed stone with most particles smaller than 5 mm (0.2 in.). Coarse aggregates consist of one or a combination of gravels or crushed stone with particles predominantly larger than 5 mm (0.2 in.) and generally between 9.5 mm and 37.5 mm (3⁄8in. and 11⁄2in.) which divided to two parts fine and coarse gravel (Alexander and Mindess, 2010).

Plastic concrete is applied in many structures such as cutoff wall, cutoff curtain, grouting and vibration damping walls to prevent the spread of pollutants from industrial factories in underground waters, controlling seepage under dams' foundation and building cutoff walls. But its' main application is to use it in the foundation of earth and gravel dams for sealing. There are various factors affecting the choice of material and plastic concrete mix design such as the rate of permeability of the desired location, site conditions, access to materials in the site, economic and administrative aspects. Plastic concrete is made of the following materials:

Bentonite slurry, the role of bentonite slurry is to keep suspended the cement, sand and gravel particles during the operation. It also increases plasticity and hold the rate of permeability down. More water is used in mix design to provide maximum flexibility in plastic concrete. This issue causes instability in fresh concrete (separation) (Brenner et al. 2003).

Cement is a factor of bonding the components of plastic concrete. If a low amount of bentonite is used in mix design, a part of cement will be deposited, and the design will be non-economic if the amount of bentonite is high. It will also be difficult to work with cement. So, a low amount of cement is considered in an appropriate mix design to have no sedimentation (Pashazad et al. 2009).

Aggregates form about 60-80% of the total volume of plastic concrete. This amount of sand and gravel prevent constant sticking of particles and thereby reduce their deformation. Gradation curves must be continuous and percentage of fine grains must be low. If the colloidal fine grains material is high, then the amount of bentonite should be reduced (Thomas et al, 1991).

MATERIALS AND METHOD

Materials

Aggregates

Figures 1 to 3 are distribution curves of the aggregates used in desired design in this research which their acceptable ranges are suggested based on different standards.

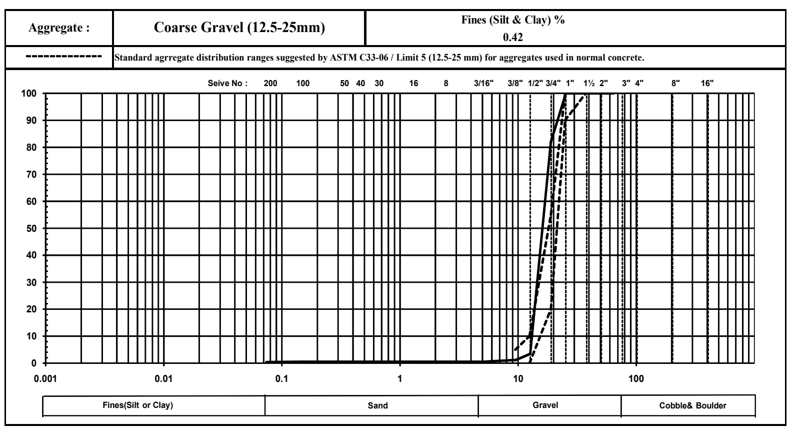

FIG 1. Distribution curve of coarse aggregates – Coarse Gravel

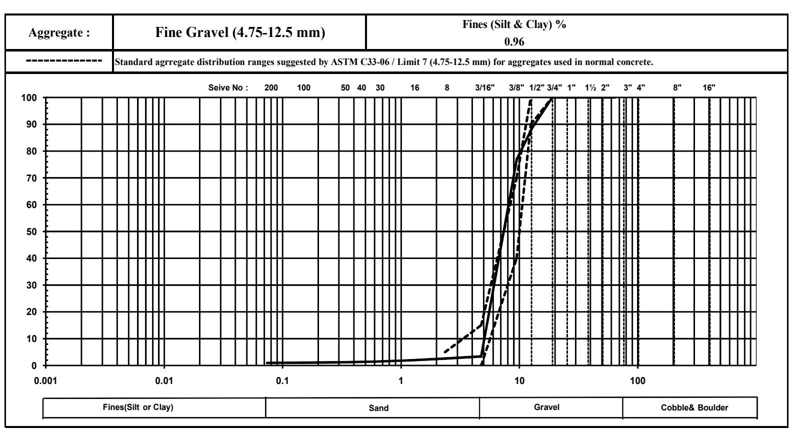

FIG 2. Distribution curve of coarse aggregates – Fine Gravel

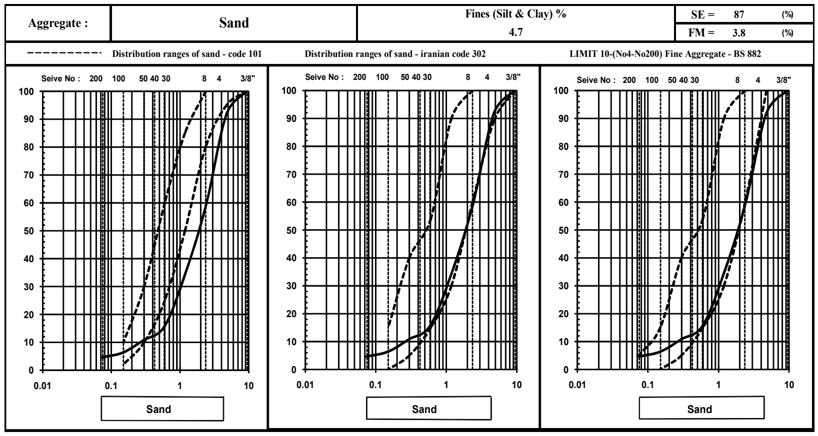

FIG 3. Distribution curve of fine aggregates - Sand

Cement

The cement type II used in plastic concrete mix designs from Bojnoord cement factory. Physical and chemical tests for determining the type of cement are provided in table 1.

Table 1. Cements tests

Component	Cement Specification	Standard Specification (ISIRI 389)
SiO2	**21.49**	**>20**
Al2O3	**4.37**	**<6**
Fe2O3	**3.57**	**<6**
CaO	**64.17**	**-**
MgO	**2.81**	**<5**
SO3	**2.18**	**<3**
L.O.I	**0.89**	**<3**

Bentonite

Since no standard is provided for technical characteristics of bentonite applied in plastic concrete, but according to the tests, its' plasticity has significant impact on plastic concrete mechanical properties. Two types of bentonite applied in this research are provided in table 2 and the tests are based on ASTM D 4318.

Table 2. Atterberg limits of two types of bentonite

Bentonite No.	LL (%)	PL (%)	PI (%)
1	532.9	68.21	464
2	387	47	340

Method of determining plastic concrete mechanical properties

A special device of measuring strength and deformation of plastic concrete is used to determine mechanical properties of this concrete (compressive strength and elasticity modulus). This device has a digital display and capability of connecting to the computer to draw the curves of stress-strain and force-movement. It has also an adjustable loading speed from 0.01mm/min to 3mm/min.

Determine compressive strength of plastic concrete

If the compressive strength of plastic concrete is high, then, the applied forces don't have desirable deformation and will be cracked and broken in low strains thus, the aim is to obtain a desired strength. The international committee of Large Dams (ICOLD, 2001) suggested the modulus of elasticity of plastic concrete 4 to 5 times more the modulus of surrounding soil. Within the test, the loading speed in scrip soils (more than typical soils and less than typical concretes) gives better results in terms of strength and modulus of elasticity. However, considering the suggestions of ASTM C469 and ASTM D 2166, speed of compression testing machine in this study was considered 0.15mm/min. For implementing the test, initially the samples surface was capped to prevent stress concentration and non-uniform distribution on the samples. Due to the low strength of plastic concrete, very fine plasters (passed from the sieve No. 300) was used for capping. Then, the device was turned on after putting the capped sample under the device jack in a vertical direction and contact with loading pages. Information of the force and deflection was stored automatically by recording device at any time; in this way, the stress-strain diagram was drawn for the sample. The maximum measured force until failure of the sample was recorded and its' compressive strength was determined based on the surface of plastic concrete sample.

Determining elasticity modulus of plastic concrete

Elasticity modulus doesn't have a proper meaning and a constant value, because primarily the soil deformation is due to relative movement of its' particles and in different stress levels, the soil behavior is different against the applied force. Thus, it is preferable to use the module or deformation coefficient. This coefficient describes the relationship between stresses and deformations. There are two general methods to calculate the linear stress module (Soroush and Mojtahedi, 2002).

-Tangent modulus is based on the slope of the tangent at any point on the curve and usually, the tangent of first part of the curve is called initial tangent modulus (ASTM D 2166).

- Secant modulus is based on the line slope between two points; usually the two points are in the range of service stress (ASTM C469).

The modulus of elasticity cannot be obtained via ASTM C469 method due to the fact that plastic concrete behavior differs from ordinary concrete. Because this method is based on the fact that behavior of ordinary concrete is up to 40% of ultimate strength of linear elastic and concrete modulus of elasticity is defined based on this behavior. Whereas, in plastic concrete not only this behavior is not linear, but also is not elastic. So, the definition of elasticity modulus of plastic concrete is not the same with ordinary concrete; secondly, the loading speed is so high that the operator is not able to read the stress-strain values (Eslamian, 2010).

In this research, elasticity modulus of plastic concrete is calculated via drawing its' diagram based on the standard of ASTM D2166 considering the slop of the curve linear region or based on equation (1) (Kahl et al, 1991).

$$E = \frac{\sigma_b - \sigma_a}{\varepsilon_b - \varepsilon_a} \tag{1}$$

σ_b : maximum stress in linear part of stress-strain curve
σ_a : minimum stress in linear part of stress-strain curve

ε_b : maximum strain in linear part of stress-strain curve
ε_a : minimum strain in linear part of stress-strain curve

Determining plastic concrete marsh

Marsh funnel (viscosity) or marsh density is measuring the time of passing a certain volume of liquid from the funnel marsh which dimensions and volume is determined; also the dimensions of outlet hole is defined. Marsh density of bentonite slurry is done in the basin before concrete production. Suitable range of marsh density is usually between 40 to 50 seconds after at least 72hr soaking bentonite in the water for finishing the absorption.

Determine optimal mix ratios (mixture proportions) of materials

Extensive field surveys have been done in this research; about 20 mix initial designs were chosen in order to investigate the effect of different mixture proportions and compressive strength of elasticity modulus (these tests were conducted on 28 days cylindrical samples with dimensions of 15*30 cm). Table 3 indicates the summary of different mixture proportions:

Table 3. Summary of plastic concrete mix designs

Mechanical Properties		Gels		Aggregates					Design No.
Density (gr/cm^3)	Slump (cm)	Marsh (sec)	Ratio of water to bentonite	Ratio of coarse aggregates to the fine aggregates (sand)	Coarse Gravel (kg)	Fine Gravel (kg)	Sand (kg)	Cement(kg)	
Mix design with bentonite No. 1									
1.8	18	52	17:1	0.79	339	244	732	90	**1**
1.8	18	54	17:1	0.56	135	330	835	100	**2**
1.8	18	52	17:1	0.80	339	244	732	120	**3**
1.8	18	54	17:1	0.56	327	164	750	130	**4**
1.8	18	54	17:1	0.65	135	330	835	130	**5**
1.9	19	54	17:1	0.80	382	468	750	130	**6**
1.9	19	54	17:1	1.13	339	244	732	130	**7**
1.9	20	53	17:1	0.80	244	341	732	140	**8**
1.9	18	55	17:1	0.56	135	330	835	150	**9**
1.9	19	55	17:1	0.56	339	244	732	150	**10**
1.9	18	50	17:1	0.67	238	287	784	150	**11**
1.9	19	54	17:1	0.80	135	330	835	150	**12**
2.2	19	55	17:1	1.13	382	468	750	150	**13**
1.9	19	50	17:1	0.67	238	287	784	200	**14**
1.9	18	50	17:1	0.56	135	330	835	200	**15**
Mix design with bentonite No. 2									
1.87	22	38	17:1	0.80	339	244	732	120*	**16**
1.85	22	37	17:1	0.80	339	244	732	130*	**17**
1.88	22	38	17:1	0.80	339	244	732	150*	**18**

RESULTS AND CALCULATIONS

Effect of cement on compressive strength and elasticity modulus of plastic concrete

Considering the fix ratios of aggregates and fixed type of bentonite and also changing the ratio of cement in the design, the design nos. 1 , 3, 7 and 10 with 90kg, 120kg, 130kg, and 150kg cement respectively, were prepared and stress-strain diagrams of each design are shown in FIG 4. Compressive strength of these concretes are increased from 3.45kg/cm^2 to 14/38kg/cm^2 after 28 days. This is in fact due to chemical reactions of hydration between water and cement and also carbonation reactions due to the presence of cement, bentonite and water which act in the mix.

According to the linear slope of the diagrams of FIG 4 and mentioned above discussions about determining the concrete modulus of elasticity, compounds of with nos. 1, 3, 7 and 10 have elasticity modulus of 2381, 3636, 6667 and 13750kg/cm^2; the relative increase of cement to 60% will increase the modulus of elasticity up to five times which is in fact the crisp of concrete and shows the high influence of cement on this property. Raising too much of this parameter in plastic concrete according to creation of conflict in behavior between concrete and the surrounding soil is not acceptable.

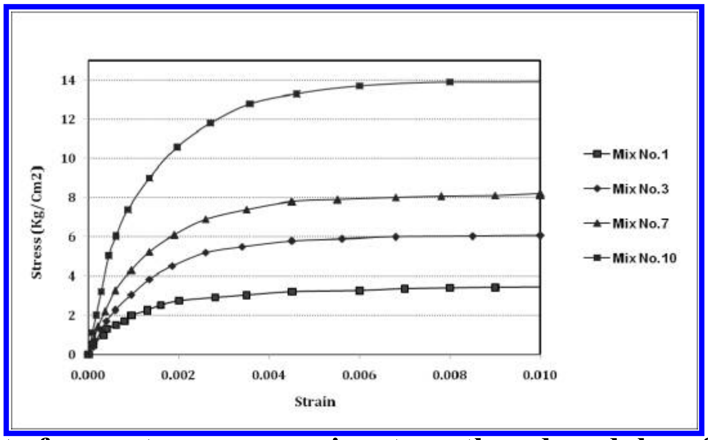

FIG 4. Effect of cement on compressive strength and modulus of elasticity of plastic concrete

Effect of the aggregate on compressive strength of plastic concrete

The designs nos. 4, 5, 6 and 7 were considered with the ratios of coarse aggregates (fine gravel and coarse gravel) to fine aggregates (sand) with 130kg of cement and the designs nos. 9, 10, 11, 12 and 13 with change in mentioned ratios and considering the amount of 150kg of cement. FIG 5 indicates changes in stress. Sinusoidal and irregular changes of different values indicate no direct effect of this parameter in compressive strength of concrete. It can be concluded that changing the ratios of fine aggregates to coarse aggregates or vice versa depending on the ratio rate can reduce or increase compressive strength of plastic concrete samples; totally, continuity of aggregate materials can increase the compressive strength. In other words, uncertain changes in increasing process of the ratio of coarse to fine indicates the lack of certain relation in compressive strength of plastic concrete. In the other word, it can be seen increase in strength by reducing the porosity inside the concrete environment. This point in this type of aggregate has reached the best strength in the ratio 0.55 (in the design nos. 4 and 9 respectively with compressive strengths of 7 and 10kg/cm^2) this ratio has shown the highest strength for two different designs. The trends of both sets of concretes strength which are drawn in form of two graphs in FIG 5, confirms above discussions and one result was obtained.

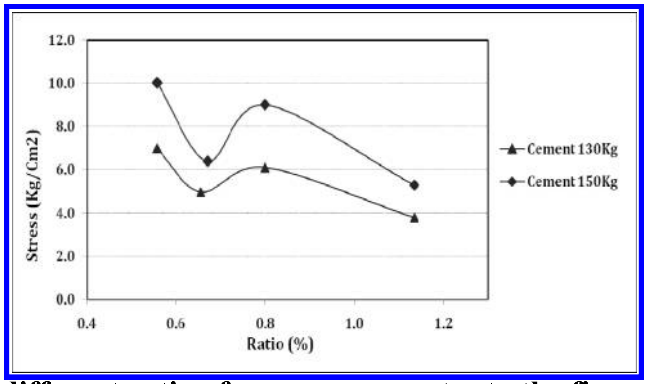

FIG 5. Effect of different ratio of coarse aggregates to the fine aggregates (sand) on compressive strength plastic concrete

Effect of bentonite on compressive strength of plastic concrete

The effect of bentonite on compressive strength of plastic concrete is evaluated by choosing the design nos. 3, 7 and 10 which were prepared with constant ratios of aggregate, 100, 120 and 130kg of cement with bentonite no. 1 (PI=464%) and also the design nos. 17, 16 and 18 with the same high ratios but with bentonite no. 2 (PI=340%). FIG 6 indicates that if all parameters are the same and also the amount of bentonite is not changed, but because the water is increased or in other words, the amount of marsh is reduced (the fixed ratio of water to bentonite of 17 was obtained 55 and 38 seconds for marsh bentonite no. 1 and 2 respectively), thus it will effect on the results of compressive strength and consequently reduce the results. As can be seen from the picture, the compressive strength of plastic concrete with bentonite no. 1 for the cements 120, 130 and 150kg was obtained respectively 6, 7.6 and 9 kg/cm^2; these numbers for plastic concrete with bentonite no. 2 was obtained respectively 4.8, 6.1 and 7.2 kg/cm^2.

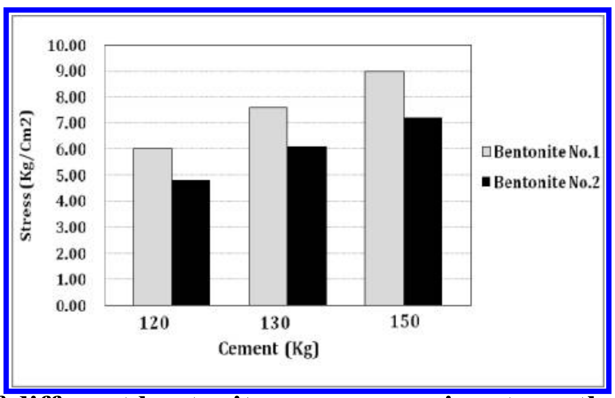

FIG 6. Effect of different bentonite on compressive strength plastic concrete

Table 4. Results of calculating the parameter A

Bentonite number	PI (%)	parameter A
1	464	7.1
2	340	5.4

Compressive strength of plastic concretes made with bentonite no. 1 was more than plastic concretes made with bentonite no. 2. The parameter A (term activity) is defined as the activity in clay soils to explain the absorption of water with clay and its' nature. In fact, this parameter indicates the clay behavior and the power of hydration of clay (Das, 2008). In case of bentonites used in this report, the A parameter of bentonite no. 1 applied in mix design differs with the bentonite used in second stage (Table 4). The value of A parameter has reduced from 7.1 to 5.4 which means the reduction of the activity of bentonite no. 2 compared with no. 1, which is reduction of hydration in bentonite no. 2 compared to bentonite no. 1 or presence of excess free water in the inside of concrete with bentonite no.2. In other words, it is obvious that the power of water absorption applied in the concrete with bentonite 2 is lower than concrete with bentonite 1 in different parts and excess water remains which reduce the strength. However, by reducing the amount of water, free water is omitted and better results are obtained.

CONCLUSIONS

In this article, different mixture proportions of plastic concrete were selected and the impacts of these percentages on mechanical properties were investigated, the results are as following:

1. Comparative results show that compressive strength and elasticity modulus of plastic concrete will be increased by increasing cement in a fixed amount of water and materials.
2. Changing the ratios of fine and coarse aggregates can lead to reduce or increase compressive strength of plastic concrete samples depending on the rate of ratios; it doesn't have a fix and uniform trend on plastic concrete strength.
3. A concrete which it's bentonite has high term activities (parameter A), its' compressive strength increases compared with concrete made of a bentonite with lower A parameter due to existence of less free water in it.

REFERENCES

Alexander M. and Mindess S., (2010), "Aggregates in Concrete, Modern Concrete Technology." *CRC Press*.

ASTM part C and D, (2013), *American Society for Testing and Materials*, USA.

ICOLD, (1985), "Filling Materials for Watertight Cutoff Walls." *Bulletin 51*, *International Committee on Large Dams*.

Thomas W. Kahl, Joseph L Kauschinger, Edward B. Perry, (1991), "Plastic Concrete Cutoff Walls for Earth Dams.", Geotechnical Laboratory.

Brenner P., Roshanzamir I. & Abed J., (2003), "Design of cofferdams.", *Technical Report, Ostour dam & Hydropower Plant Project*.

Institute of Standards and Industrial Research of Iran (ISIRI), (2001), ISIRI Number 389, Specification for portland cement, 8th Edition.

Das B. M., (2008), "Fundamentals of Geotechnical Eng.", 3th Ed., *Thomson,* USA.

Pashazadeh A., Kiakhosravi M., Ganjian V., (2009). "Estimate appropriate plastic concrete mix design of cutoff walls to control water seepage under the earth dam foundation.", *Water Science Research Quarterly*, No.1 (in Persian).

Eslamian F., (2000). "Methods and results of measuring Young's modulus of plastic concrete cutoff wall of Karkhe dam." 4th conference of dam construction. Iran, Tehran.

Soroush M., Mjtahedi A. (2002). "An overview of design and implementation of plastic concrete cutoff walls in dams' foundation." *Proceedings of specialized and workshop articles of special issues of designing dams and its' related organizations*. Isfahan Uni. of Tech. Oct. (in Persian).