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Examining the Mixing Plan and the Results of the Plastic Concrete

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Abstract

In order to control seepage from the dam, various methods are used to reduce water seepage. One of the methods of reducing the permeability of the water according to its material is the formation of cut-off walls and filling them with plastic concrete materials. In this study, it has been tried to study the mixing plan of the plastic concrete of the main body of the cut-off wall of the Nargesi dam and to determine the relationships between results of different ages of compressive strength and elasticity modulus of 108 panels of cut-off wall in this project. The results indicate that the growth rate of elastic modulus in a period of time is less than the growth rate of the compressive strength, and in other words, the plasticity of the concrete is changed less over time. The results also show that the passage of time has a great influence on the compressive strength and modulus of elasticity and the passage of time, which is very effective in designing cutoff wall, significantly increases the compressive strength and modulus of elasticity. The relationship between the time parameter and the compressive strength is discussed in the present article.

Keywords: Compressive Strength, cut-off Wall, Elasticity Modulus, Empirical Relations, Plastic Concrete

1.Introduction

Dam construction projects may be essential in most countries due to the water crisis. One of the main and undoubtedly most important parts of this huge project is the cutoff walls. The inadequacy in cutoff walls construction and the lack of comprehensive information about the behavior of its components could cause the project to be destroyed or obsolete, given the high price it may cost.
Due to the abundant use of plastic concrete and its major application in the cut-off walls of the dam construction projects, plastic concrete has great importance. Studying a variety of the concrete's mixing plans and also modulus and determining the relationships between strength and process time seem necessary. Today, there are many articles on other types of concrete and civil engineers work with them, but plastic concrete, on the contrary to its high importance, is unknown for most engineers [1],[2].

This type of concrete has a very high strain and sensitivity which will have more complicated functions than conventional concrete. Considering the high cost of cut-off wall in dam construction in projects, if the plastic concrete is not prepared according to technical specifications, the dam may have cut-off problem and may be completely damaged or obsolete [1], [2].

Therefore, it is necessary to examine the topic in terms of making plastic concrete and its aspects, as well as in terms of recognizing the exact behavior of this concrete and its behavior over time. As there is usually a long time gap between the time of the construction of the walls and the exploitation stage, it is very important to estimate the strength relationships for the exploitation time.

Due to the flood phenomenon under the dams, in most cases underground water flows exist and water seepage affects the efficiency and proper function of the dam. The pressure of water and its outlet path through the dam foundation can be dangerous for dam's permanent installations. The excessive water seepage in the basement and dam body, in many cases, has resulted in damages to the earth dams. In all of the earth dams, the presence of water seepage is inevitable, but it is certain that proper cut-off methods should be used to minimize seepage to an acceptable level [3].

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The main application of the cut-off walls is for the underneath of the earth or pebble dam. Due to its high deformation, low permeability and proper compressive strength against forces, their use in loose soils, and saturated fine grains, cutoff method is often the most cost-effective method. Among the cut-off methods, the use of cut-off walls is very useful in alluvial foundations, and it can be said that the best cut-off option in these areas is the use of plastic concrete cut-off walls.

During concreting, bentonite slurry keeps gravel, sand and cement suspended in plastic concrete, which reduces the permeability during the setting time of concrete) and, according to the ICOLD proposal, a bentonite slurry is used to enhance the ductility of concrete [4]. The mixing plan of plastic concretes should have a permeability coefficient within the range of approximately 10^{-7} to 10^{-9} m / s and slump in the range of 15 to 22 cm. In general, bentonite is used in civil engineering sciences for cutoff purposes [5-13].

It should be noted that the use of plastic concrete cut-off walls under dams, in addition to adequate strength and durability against erosion, should have considerable ductility and flexibility to endure earthquake loading or burst load without cracking and losing cut-off attribute [1].

Kazemian et al. [14] studied the changes of various amounts of bentonite in plastic concrete and its physical properties. This study showed that as the bentonite increases, compressive strength and elasticity modulus are greatly reduced. In this research, to determine the elasticity modulus of plastic concrete by drawing a stress-strain diagram, according to ASTM D2166 standard, taking into account the gradient of the linear region of the graph, the relation $E = (\sigma b-\sigma a) / (\varepsilon b-\varepsilon a)$ in which σb is the maximum stress in the linear region of stress-strain curve, σa is the minimum stress in linear stress-strain diagram, εb is the maximum strain in the linear region of stress-strain curve and εa is the minimum strain in the linear region of stress-strain curve, elasticity modulus.

Gholipour [15] studied the performance of plastic concrete in the implementation of cut-off dams (a case study of Karkhe Dam). In this research, plastic concrete of Karkheh Dam was studied using fusing iron slag. In this research, the permeability, single axial pressure and flexibility tests were performed on the samples. The results of the experiments showed that by increasing the consumption of slag up to 12.5%, the permeability of the samples decreased to about 80 times and with a consumption of 15% slag by 197 times. While the elasticity modulus increases significantly with the use of slag in the range of 10 to 12.5% cement weight.

Pashazadeh et al. [16] evaluated the design of a mixture of suitable plastic concrete with a composite method in separating walls to control the sediment under the earth dam. In their study, the use of concrete materials in the separator wall has traditionally attracted much attention due to its low permeability and high hydraulic gradients caused by underground drainage. The use of conventional concrete with a high elastic modulus may encounter problems such as wall imperfections, which occurs due to the dynamic pressure drop in the wall. To solve this problem, adding a certain percentage of clay (bentonite) to plastic concrete materials, reduces the hardness of concrete and also elasticity, which results in better flexibility and more. It has been shown that the addition of bentonite (clay and drilling mud) to plastic concrete materials reduces the risk of hydraulic fracturing and cracking.

Falaki [17] studied the mechanical properties of plastic concrete-containing bentonite using waste rubber powder. The purpose of this study was first to obtain the optimal amount of bentonite in the mixing plan of plastic concrete and then by the optimal mixing plan, obtaining the permissible percentage of replacement of waste rubber powder to the sand with maintaining proper mechanical properties. Further, consideration was given to the amount of changes in the mechanical properties of plastic concrete containing waste rubber for different percentages of this waste, which is a weight substitute for sand.

For this purpose, in the mixing plans of this study, waste from rubber powder in a size smaller than 1 mm and replacement of 3%, 7% and 10% weights by fine particles with different amounts of bentonite and water to cement ratio of 0.8 were compared with its mechanical properties with ordinary plastic concrete. To study the properties of plastic concrete, compressive strength, tensile strength, bending, elasticity modulus, water absorption, contraction, ultrasonic and electron microscopy tests were performed. The results indicated that by increasing the amount of rubber powder, a decrease in the compressive strength, flexural strength, tensile strength and elastic modulus of the plastic concrete would be seen. However, by increasing the amount of bentonite in the plastic concrete, one can partially control this negative effect and make concrete with similar properties to the original plastic concrete which contains waste rubber powder.

1.Evaluation of the Results of the Plastic Concrete of the Cut-Off Wall of the Main Body of Nargisi Dam

1.1.Nargesi Embankment Dam Site

The Nargesi embankment dam is located on Shirinrood River, approximately 45 km southeast of Kazerun city in southwest of Iran (Fig. 1). The dam is categorized as an earth-fill embankment type with central impermeable clay core. The main goal of the dam is flood control, power generation and water supply. Fig. 2 shows view of Nargesi Dam and related structures.

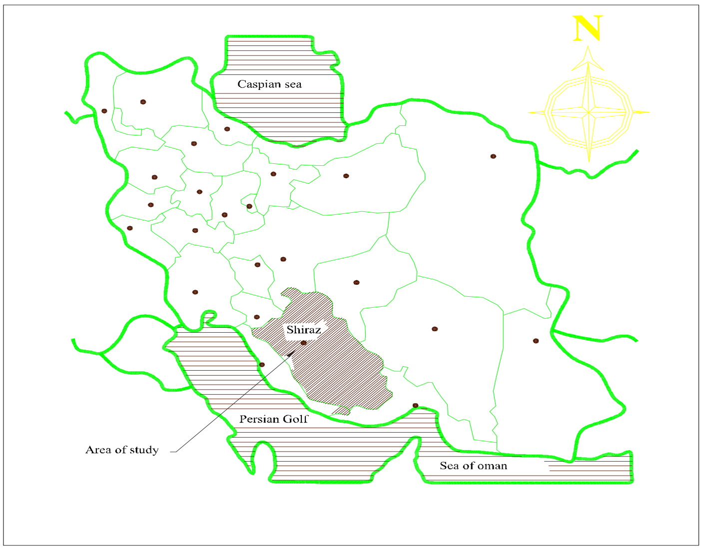


Fig. 1. Location Map of the Nargesi Dam Site

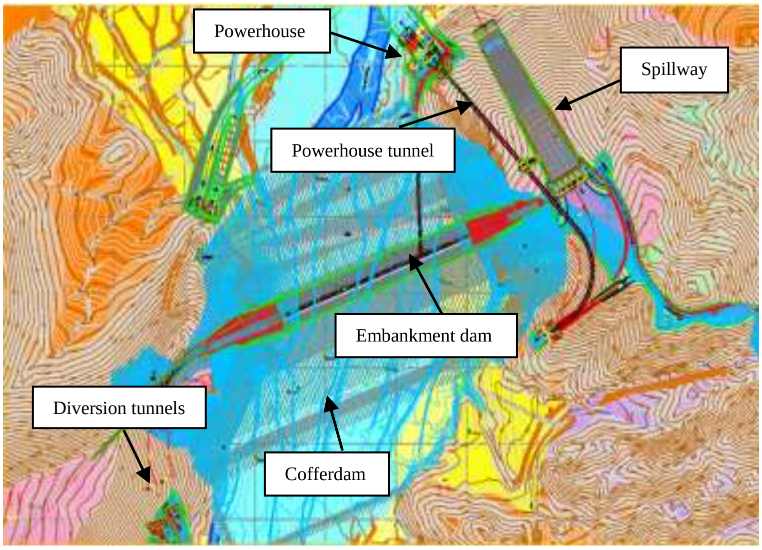


Fig. 2. View of Nargesi Embankment Dam and Related Structures.

The type of dam is limestone with clay core, the head of the river bed is 77.5 meters, the crest length is 600 meters, and the crest width is 10 meters. At the axis of this dam, the main body of the cut-off wall is drilled approximately 264 meters long and the average depth of 30 meters.

The method of drilling the cut-off wall of this project is discontinuous, in this way, the panels of the cut-off wall are drilled and run alternatively. In this method, the site of the cut-off wall is divided into S and P panels. Initially P panels are drilled and concreted, and after 28 days or after concrete's suitable initial set, P panels with drilling machine, S panels will be drilled and concreted by observing some suitable overlap. The width of the wall is different depending on the layout and size of the drilling device. In this project, the width of the wall is 80 cm and the length of the panels is 2.4 meters. After complete drilling of the S and P panels, an entirely integrated wall was finally created. The view of the cutoff wall panels is shown in Fig. 3

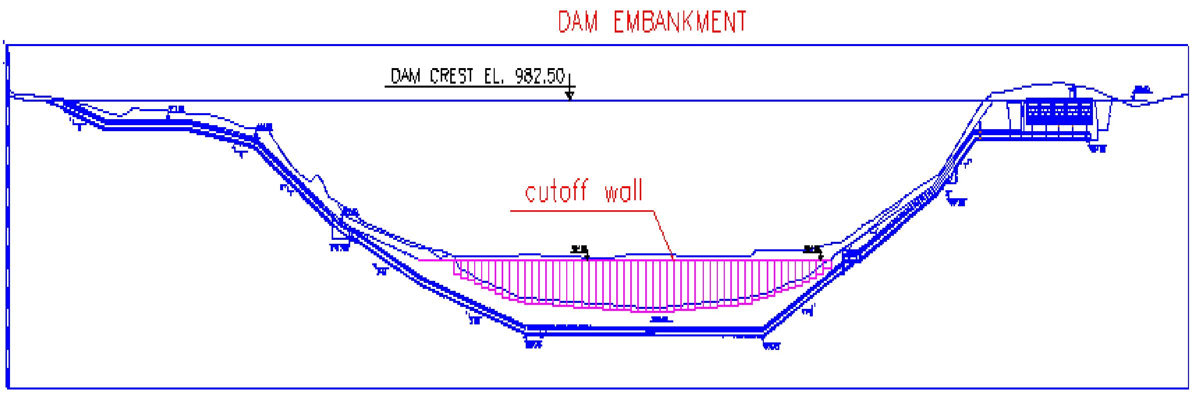


Fig. 3. Cross-Section of the Dam Body and Cutoff Wall

2.SPECIFICATIONS OF THE MATERIALS USED IN THE MIXING PLAN CONSUMABLES

2.1.Stone Materials

The used rock is a combination of broken and natural materials and is derived from the mines of the Shirin Roud River, which originates from the springs of Arjan plain. The specification of these materials is in accordance with Table 1.

Table 1
The distribution of specifications *of the stone materials*

sand	Pea gravel	Almond gravel	Sieve number	(mm)Sieve size
100	100	100	1 1/2	38.1
100	100	100	1	25.4
100	100	93.3	3/4	19.05
100	100	22.22	1/2	12.7
99.7	73.6	2	3/8	9.52
99.2	1.8	0.5	4	4.76
80.4	0.1	0	8	2.36
60.1	0	0	16	1.18
34.8	0	0	30	0.59
19.3	0	0	50	0.298
5.1	0	0	100	0.149
1.6	0	0	200	0.074

a) Cement

Cement used in this study is Fars cement type 2, the characteristics of which are listed in Table 2.

Table 2
The distribution of specifications of the cement

characteristics	Compressive strength (kg/cm^2)			Final curing period (minute)	Initial curing period (minute)	Specific area (cm^2/g)
	28 days	7 days	3 days			
results	315	175	100	195	130	2800

b) **Bentonite**

Bentonite used in the manufacture of concrete is from Darin Kashan company's bentonite, the specifications of which are given in Table 3.

Table 3
The distribution of specifications of the bentonite

characteristic	Quantity measured
LL	314.5
PI	283.3
Gs	2.79
Classification	CH
Clay Fraction	72
Silt Fraction	23
Sand Fraction	1
w opt %	23
Dry density	1.56
SSA (m2/gr)	418
CEC (cmol/kg)	68.2

c) **Water**

Water used in the manufacture of concrete is from drinking water of the workshop, which PH is 7.5.

d) **Mixing plan**

The mixing plan and specifications of the plastic concrete of the Nargesi dam's cut-off wall are in accordance with Tables 4 and 5, which is in accordance with the wanted technical specifications of the design. The required compressive strength is considered for a 7-day age range of approximately 0.8 to 1.5 MPa and for the age of 28 days is 1.5 to 2.5 MPa and the Young's modulus for 28 days is between 200 and 400 MPa.

Table 4
The distribution of the amount of materials used to make 1 cubic meter of plastic concrete

Consumed materials	(kg)
cement	130
bentonite	40
water	382
sand	705
Pea gravel	520
Almond gravel	259

Table 5
The distribution of approved mixing plan of the cut-off wall in Nargesi dam

(Kg)Cement weight	**(kg)Bentonite weight**	**(W/B)Water to bentonite proportion**	**slump (cm)**	**28 days (kg/cm^2)**	
				(kg/cm^2)Compressive strength	**(kg/cm^2) Elasticity modulus**
130	40	9.55	20.5	13.8	2750

The manufacturing process of the plastic concrete in this study is as follows. The bentonite slurry was first made according to portions mentioned in the mixing scheme and turned into gelatin after 24 hours of processing. Then the other concrete-forming materials such as dry sand, gravel and cement were mixed in a betonyer for 5 minutes and then gently bentonite slurry was added. All the concrete ingredients were then mixed in the betonyer for 15 minutes. After sampling for 24 hours, the samples were kept in the mold at the laboratory temperature (20 ° C) and then the molds were opened and stored in a pond containing water. After 28 days of sampling, the samples were taken out of the pond and the two ends of the specimens were changed to a flat surface before being put under a bentonite cracker jack in order to uniform loading by melted sulfur and then tested.

At the next step, all panels are sampled and Curinged as follows (Fig. 4).

Fig.4. Curing Concrete Samples

In Table 6, the results of pouring concrete of the cut-off wall panels of the main body of the Nargesi dam project are fully included for different ages.

Table 6
Specifications of the strength and elasticity modulus of the cut-off wall (kg/cm^2)

column	panel	11 days strength	42 days strength	90 days strength	11 days modulus	42 days modulus	90 days modulus
1	P1 S1 P2	14.1	20.5	26.5	3475	3711	4701
		14	21.2	26.9	3451	3870	4735
2	S2	8.1	14.5	15.7	2011	3266	3810
		8.4	15.5	16.4	2057	3237	3923
3	P3	9.2	13.5	15.7	2354	3722	3925
		9.1	14.3	16.2	2317	3786	3978
4	S3	9.7	13.2	14.2	2275	3739	3590
		9.7	14.1	14.5	2259	3488	3618
5	P4	13.4	20.4	21.2	2845	4242	4722
		13.8	20.3	21.2	2878	4217	4731
6	S4	8	13.8	16.7	2178	3588	4077
		8.1	14.6	16.6	2190	3679	4015
7	P5	13.1	18.4	23.6	2879	3510	4886
		13	19.7	23.2	2894	3567	4832
8	S5	9.3	14.6	18.5	2412	3011	4013
		9.8	14.8	18.2	2456	3072	3967
9	P6	8.7	13.9	16.5	2091	3319	4026
		9.2	14.2	16.9	2134	3368	4091
10	S6	6.6	11.1	13.1	1876	2496	3385
		6.5	11.6	12.9	1852	2519	3353
11	P7	10.5	19.2	21.5	2311	4216	5034
		10.7	18.7	20.7	2358	4216	4976
12	S7	11.6	17.5	19.1	2445	3326	4136
		11.3	17.2	19.6	2420	3300	4197
13	P8	8.3	12.6	15.4	2144	3160	3564
		8.1	12.9	14.7	2108	3177	3525
14	S8	7.6	10.3	10.8	1982	2324	2546
		7.1	10.2	11.1	1976	2232	2553
15	P9	10.3	17.1	18.7	2262	3250	4004
		10.3	16.9	19.2	2244	3216	2023
16	S9	11.4	18.6	20.7	2458	3590	3877
		11.2	18.3	20.9	2433	3510	3991

Table 6 (continued)

column	panel	11 days strength	42 days strength	90 days strength	11 days modulus	42 days modulus	90 days modulus
33	P18	6.9	12.5	14.1	2108	3028	3645
		7.3	13.1	14.2	2145	3054	3698
34	S18	13.2	19.7	24.3	3358	4296	5158
		13.2	19.9	23.2	3337	4369	5053
35	P19	13.3	22.4	23.2	2755	4880	5176
		13.9	21.9	23	2773	4769	5133
36	S19	22.2	32.9	33.7	4247	6543	6710
		22.6	31.8	33.2	4225	6385	6680
37	P20	8.2	15.6	20.3	2145	3226	4002
		8.1	15.8	19.6	2117	3251	3975
38	S20	10.4	18.2	20.7	2145	3280	3741
		10.5	18.1	20.7	2133	3251	3765
39	P21	5.8	10.3	13.8	1157	2018	2750
		5.7	10.4	13.2	1140	2037	2678
40	S21	13.1	18	19	2655	3416	4142
		12.2	18.6	19.8	2472	3466	4168
41	P22	5.7	11	12.8	1256	2451	2715
		5.8	11.1	13	1289	2477	2761
42	S22	7.1	13.2	15.2	2547	3486	3992
		7.1	13.1	15.5	2553	3451	4060
43	P23	8.4	12.2	16.1	2320	2845	3562
		8.5	12	16	2351	2811	3527
44	S23	11.2	18	22	2411	3350	4918
		11.4	18.4	22.3	2487	3389	4937
45	P24	6.5	11.9	15.3	1622	2937	3505
		6.6	12.2	15.6	1688	2984	3576
46	S24 S25	6.8	11.5	12.6	2045	2589	3063
	P25	6.7	12.2	12.9	2076	2655	3067
47	P25	8.8	13.7	16.6	2458	2864	3280
		9	13.6	16.5	2371	2851	3274
48	P26	5.7	9.7	11.2	1254	2176	2715
		5.7	9.8	11.4	1270	2250	2768

Table 6 (continued)

column	panel	11 days strength	42 days strength	90 days strength	11 days modulus	42 days modulus	90 days modulus
49	S26	7	13.7	15.6	2122	3253	3578
		7.5	13.9	16.2	2160	3288	3615
50	P27	7.4	11.7	14.9	1506	2747	3880
		7.9	11.9	15.3	1547	2784	3918
51	S27	6.9	11.4	15.3	1541	2840	3910
		6.8	11.5	15.6	1522	2879	3945
52	P28	7	12.4	14.1	1864	2654	3980
		7	12.3	14.2	1850	2689	3994
53	S28	7.3	12.6	15.6	1864	2959	4145
		7.3	12.8	15.5	1877	2981	4110
54	S29	10.8	17.4	22.1	2881	3285	3904
		10.6	16.8	22.5	2842	3144	4000
55	P30	7.1	11.2	15.1	2091	2784	3605
		7.2	11.7	15.2	2104	2800	3634
56	S30	7.9	13.4	14.1	1981	3149	3223
		7.8	13.3	14	1972	3014	3212
57	P31	6.1	11.8	14.7	2118	2626	4053
		6	11.6	14.6	2147	2587	4018
58	S31	15.2	29.8	34.9	3284	5449	5910
		15.5	29.6	35.5	3301	5486	5848
59	P32	8.1	11.9	16.1	2054	2771	3604
		8.3	11.9	15.9	2076	2759	3533
60	P33	9.6	20.6	23.4	2570	4221	4533
		9.5	21.3	23	2550	4365	4517
61	S33	6.7	12.8	13.2	1927	3003	3408
		6.8	12.9	13.6	1905	3010	3424
62	P34	7	12.4	18.3	1978	2987	3688
		6.9	12.7	18	1924	3069	3645
63	S34	4.6	8.5	9.5	1124	2579	3026
		4.7	8.3	9.6	1109	2410	3040
64	P35 S35 P36	8.4	13.5	18.6	2291	3047	4009
		8.3	13.4	18.4	2285	3015	3947

Table 6 (continued)

column	panel	11 days strength	42 days strength	90 days strength	11 days modulus	42 days modulus	90 days modulus
65	S36	7.9	12.7	13.7	2178	3354	4157
		8	12.5	14	2201	3316	4165
66	P37	6.7	13.8	15.6	1794	3315	3641
		6.7	14.1	15.9	1758	3420	3687
67	S37	6.7	10	12.9	1830	2415	3248
		6.9	10.6	13	1843	2466	3265
68	P38	9	14.9	17.4	2410	3324	3824
		8.9	14.9	17.5	2378	3309	2851
69	S38	7	12.1	12.8	1985	2924	3296
		7	12.5	13.3	1921	3084	3484
70	P39	6.8	14.2	16.7	2201	3488	4650
		6.9	14	16.8	2232	3540	4691
71	S39	6.7	11.6	15.9	2410	2740	3845
		6.8	11.8	16.2	2317	2755	3885
72	P40	9.2	15.9	22.1	2321	3131	3857
		9.1	16.3	21.9	2329	3254	3836
73	S40	5.2	9.3	11.8	1250	2684	3335
		5.2	9.4	11.7	1135	2624	3324
74	P41	12.25	19.3	22.68	2380	4319	4684
		12.18	18.62	23.22	2344	4335	4771
75	S41	9.3	15.7	17.2	2743	3314	3678
		9.1	15.9	17	2712	3361	3645
76	P42	6.6	12.2	14.2	2205	2916	3352
		6.6	12.3	14.7	2187	2934	3378
77	S42	7	13.9	14.9	1710	3256	4018
		6.9	13.7	15.1	1689	3231	4054
78	P43	8.7	14.9	19.6	2236	3878	4467
		8.5	14.8	19.5	2219	3889	4418
79	S43	5.7	10.4	12.4	1327	2350	2811
		5.7	10.5	12.7	1318	2389	2839
80	P44	10.4	14.4	17.8	2615	3807	4101
		10.5	14.3	18.1	2628	3756	4123

Table 6 (continued)

column	panel	11 days strength	42 days strength	90 days strength	11 days modulus	42 days modulus	90 days modulus
81	S44	8	12	13.8	2011	2619	2841
		7.9	12.3	14.2	2008	2634	2875
82	P45	9.8	17	20.9	2866	3769	5279
		9.4	17.2	21.5	2789	3775	5344
83	S45	6.2	10.8	11.8	1675	2413	3047
		6.3	10.9	11.7	1689	2459	3015
84	P46	7.1	12.9	14.5	1775	3159	3335
		7	13	14.6	1738	3184	3361
85	S46	7.2	11.9	15.4	1728	2819	3476
		7.3	12	15	1804	2841	3418
86	P47	5.4	10.7	12.7	1587	2336	3135
		5.3	10.9	12.9	1501	2345	3163
87	S47	6.5	10.7	13.8	1744	3210	3684
		6.4	10.9	13.6	1775	3277	3621
88	P48	6.6	12	16.1	2257	2680	3498
		5.8	11.9	16.1	2116	2627	3487
89	S48	9.6	14	17.1	2927	3528	4125
		9.9	13.9	17.2	2956	3504	4134
90	P49	3.9	9.4	10.8	1413	2889	3219
		4.9	10.3	10.9	1660	3056	3231
91	S49	10.9	14.5	17	2237	3153	3561
		10.8	15.2	17.1	2185	3264	3597
92	P50	17.2	30.1	37.8	3574	5144	5758
		17.2	31	38.5	3551	5207	5992
93	S50	9.6	18.3	18.6	2213	3325	3490
		9.4	18.4	19.1	2181	3357	3520
94	P51	7.4	12.8	14.5	2082	2724	3214
		7.2	12.8	14.5	2043	2739	3198
95	S51	8.5	12.4	14.1	2096	2915	3273
		8.6	12.7	14	2113	2942	3163
96	P52	5.4	9.5	11.1	1884	2331	2569
		5.2	9.8	11	1827	2367	2535

Table 6 (continued)

column	panel	11 days strength	42 days strength	90 days strength	11 days modulus	42 days modulus	90 days modulus
97	S52	7.1	14.7	15.8	1985	3453	3554
		6.9	15	16.3	1927	3485	3669
98	P53	19	32.5	50.2	3498	5749	6325
		18	33.3	50.3	3385	5801	6385
99	S53	5.7	11.4	11.7	1829	2929	2981
		5.6	11.5	11.8	1810	2934	3004
100	P54	9.1	17.8	18.3	2181	3442	3650
		9	17.7	18.7	2064	3413	3698
101	S54	14.1	22.4	24.9	3209	4861	5017
		13.4	22.3	25.1	3188	4863	5043
102	P55	11.9	19.6	21.7	2760	3884	4446
		11.6	19.7	21.5	2717	3985	4438
103	S55	16.3	27.1	38	3220	5210	5941
		16.6	26.4	37.1	3301	5180	5774
104	P56	10.2	15.9	18.8	2155	3196	3649
		9.7	15.7	18.9	2099	3120	3688
105	S56	12	19.5	23.9	2675	3807	4207
		11.8	19.6	24.3	2641	3795	4212
106	P57	7.4	15.3	18.6	2138	3391	3789
		7.2	14.9	17.9	2098	3310	3704
107	S57	14.7	23.1	24.6	3528	4108	4510
		14.9	22.5	24.8	3567	4179	4535
108	P58	8.3	15.3	15.7	2171	3420	3619
		8.1	15.2	16.3	2157	3392	3811

2.Objectives of the Results' Evaluation

The purpose of the results evaluation is to analyze the results of plastic concrete statistically at this stage, and find relationships that can be very important. One of the important properties of plastic concrete is a significant increase in strength and elastic modulus over time. This important issue is often ignored by designers. For the importance of this topic and finding highly effective relationships with regard to the strength and elastic modulus of plastic concrete, a statistical analysis on the results of experiments was carried out on the plastic concrete cut-off wall of Nargesi dam.

a) **Average**

The simplest method of statistical analysis to examine the result of generating a product, which is created from the production of identical components, is to use the average result of products. In the method of constructing the cut-off wall, which consists of joining the panels, the result of the strength average and elastic modulus provides the appropriate basic information of the cut-off wall's behavior (numbers 11.42 and 90 are concrete ages).

$\bar{\sigma}_{11} = 9.296\, {kg}/{cm^2}$ $\overline{E_{11}} = 2283.685\, {kg}/{cm^2}$

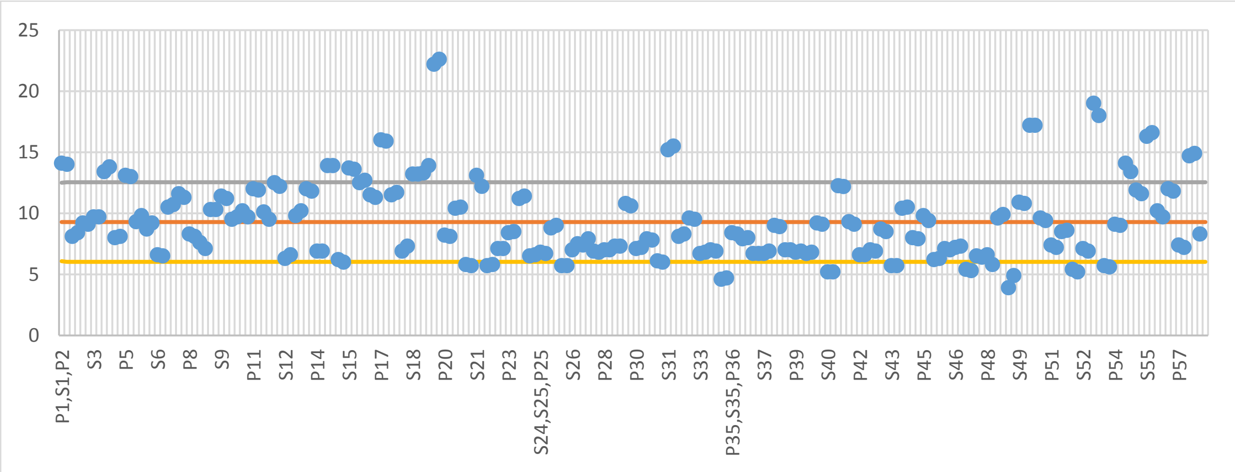
$\bar{\sigma}_{42} = 15.51\, {kg}/{cm^2}$ $\overline{E_{42}} = 3381.718\, {kg}/{cm^2}$

$\bar{\sigma}_{90} = 18.217\, {kg}/{cm^2}$ $\overline{E_{90}} = 3926.157\, {kg}/{cm^2}$

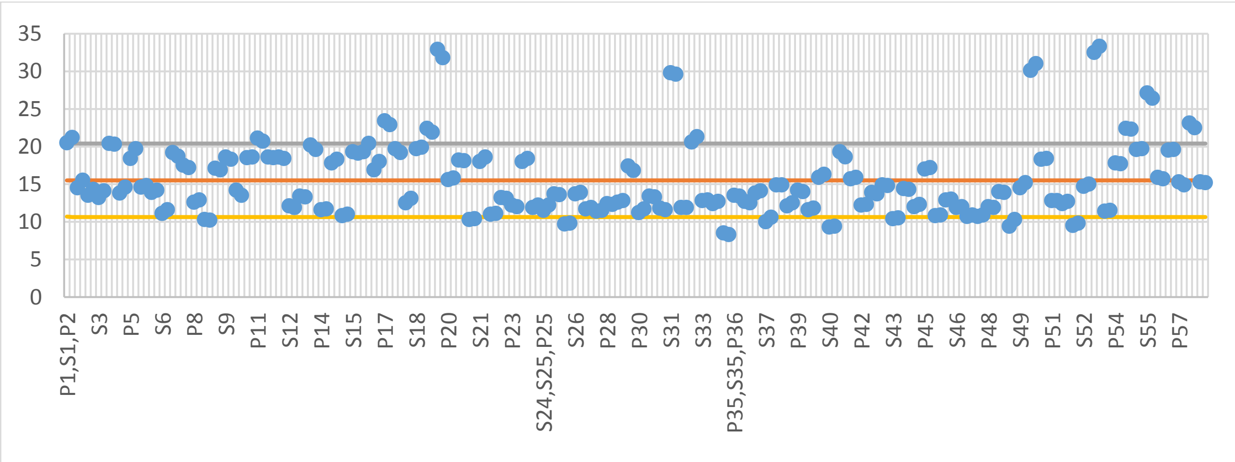
Since the type of cement of the type 2 cement was used in the construction of the cut-off wall's plastic concrete in Nargesi dam, the 42-day results are equivalent to the 28-day results of concrete with type 1 cement. Therefore, according to the average results of 42 days, its compliance with the instruction of the concrete construction design as well as the provisions of publication 13 (filler materials for cut-off walls construction in accordance with B51 Bulletin of the ICOLD letter) based on a 28-day compressive strength of plastic concrete is equal to15 kg / cm2 (1.5 MPa) and an elastic modulus is equal to 4 to 5 times of the average modulus of the drilling site (Approximately 4000 kg / cm 2 in this project) confirms the proper achievement of the average result based on the criterions of the plan.

b)Standard deviation

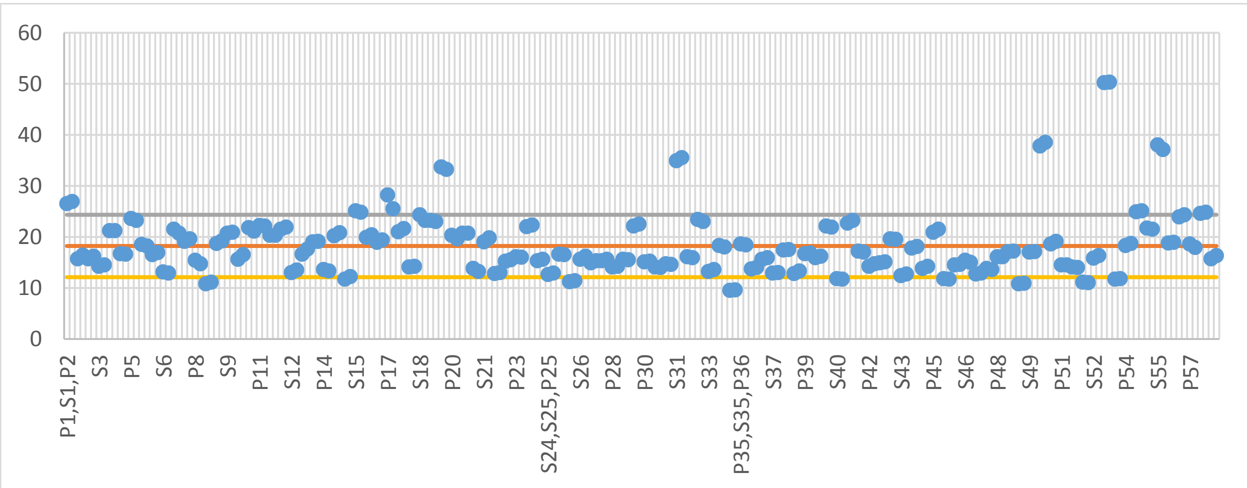
Since the algebraic aggregation of the data in the mean method causes the uncertainty of the distance between the results and the average or production standard, in other words, the negative and positive distance between the results and mean may go to zero, but each of them alone is unacceptable, therefore, the standard deviation method is used to evaluate the results. The calculations in this method are based on the square cloth of the difference between each result and the mean, and it defines the error value in the results. In the tables below, the standard deviation, mean and the distribution of results based on the lifetime of the plastic concrete are shown for compressive strength and elasticity modulus.



(a) Compressive strength of 11-day age

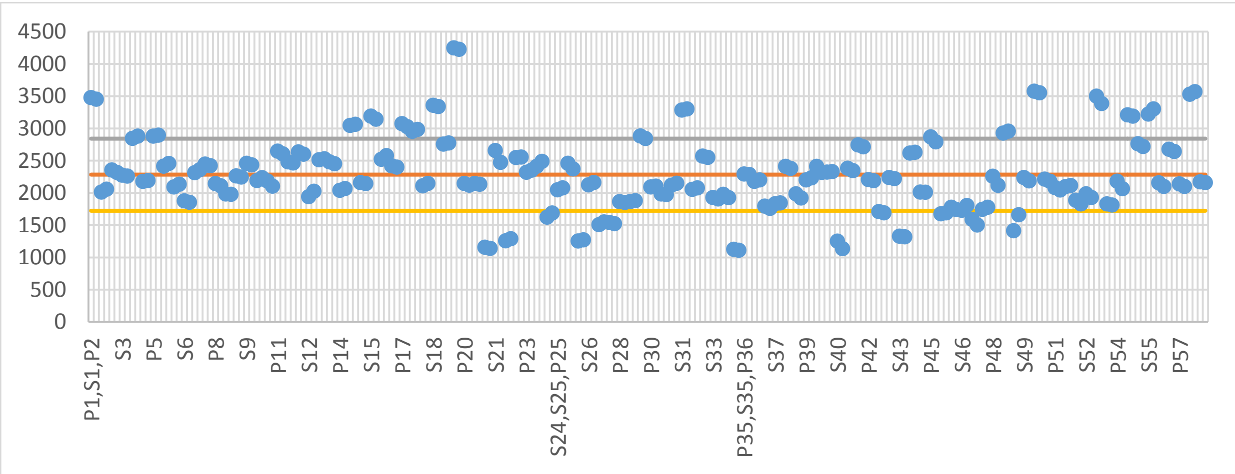


(b) Compressive strength of 42-day age

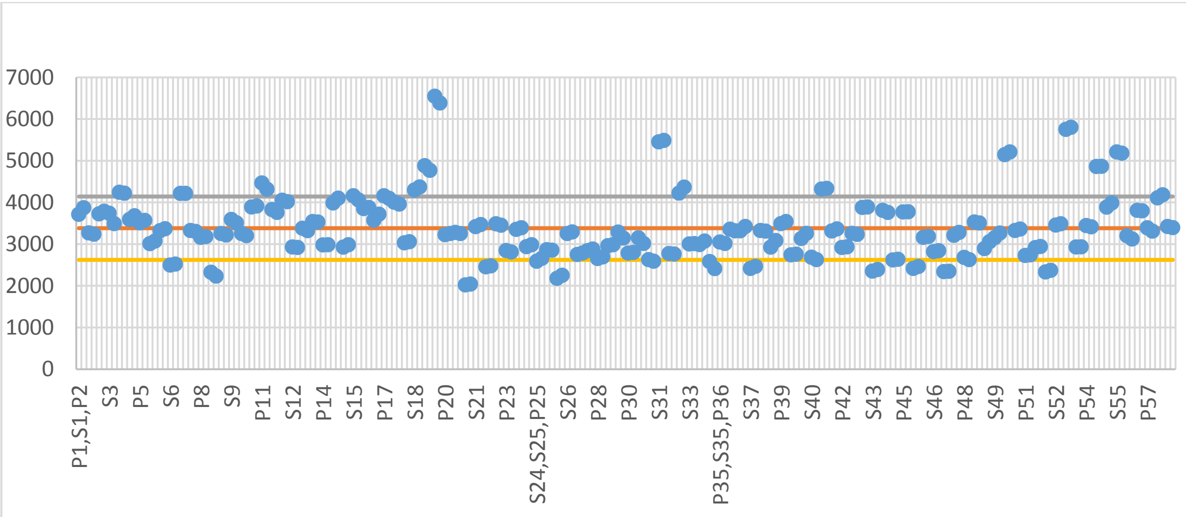


(c) Compressive strength of 90-day age

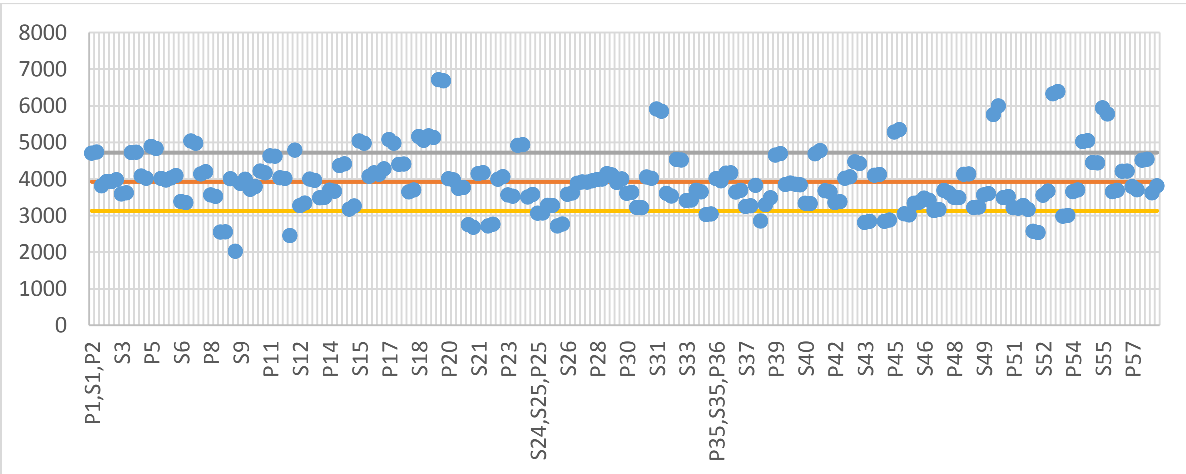
Fig.5. Compressive strength in different ages



(a) Elasticity modulus of 11-day age



(b) Elasticity modulus of 42-day age



(c) Elasticity modulus of 90-day age

Fig. 6. Elasticity modulus in different ages

If we show the standard deviation with the letter e, we will have:

$e\sigma_{11} = \pm\, 3.21\ {kg}/{cm^2}$ $\quad$ $eE_{11} = \pm 558.751\ {kg}/{cm^2}$

$e\sigma_{42} = \pm 4.81\ {kg}/{cm^2}$ $\quad$ $eE_{42} = \pm 758.772\ {kg}/{cm^2}$

$e\sigma_{90} = \pm 6.11\ {kg}/{cm^2}$ $\quad$ $eE_{90} = \pm\ 795.47\ {kg}/{cm^2}$

According to the above diagrams, more than 90% of the results are within the standard deviation range.

b) Regression Line

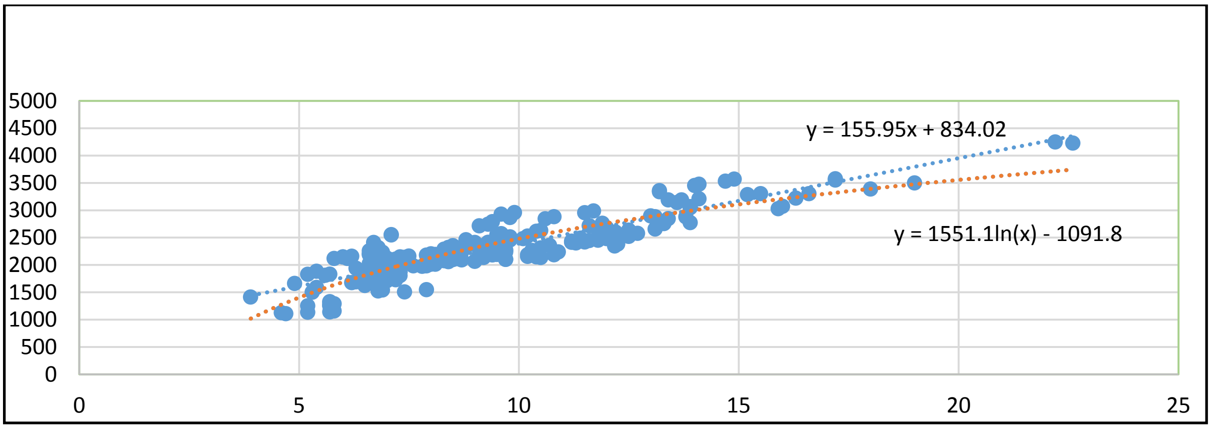
In statistical models, regression analysis is a statistical process for estimating relationships between variables. This method involves many techniques for modeling and analyzing specific and unique variables when focusing on relationships between dependent variable and one or more independent variables. Regression analysis specifically helps to understand how the value of the dependent variable varies by changing each of the independent variables and by the constancy of other independent variables.

The most common use of regression analysis is the conditional and mathematical expectation's estimation of the dependent variable of independent determinant variables, which is equivalent to the mean value of the dependent variable when the independent variables are constant. Its least use is the focus on percentile or spatial parameters of the conditional distribution of the dependent variable from a given independent variable. In all cases, the goal is to estimate a function of independent variables that is called regression function. In regression analysis, determining the dispersion of the dependent variable around the regression function is considered, which can be explained by a probability distribution.

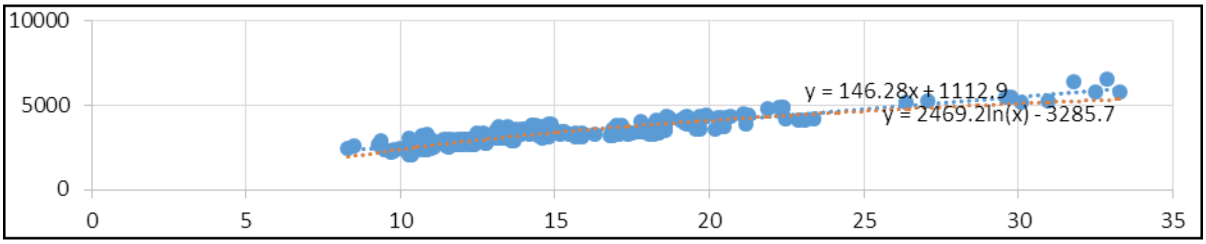
Regression analysis has been widely used for prediction. Regression analysis is also used to understand the relationship between independent and dependent variables and the form of these relationships. Under certain conditions, this analysis can be used to infer excellent relationships between independent and dependent variables.

Many techniques for regression analysis have been developed. Familiar methods such as linear regression and least squares, which are parametric, are actually estimated in this regression function under a limited number of unknown parameters of the data.

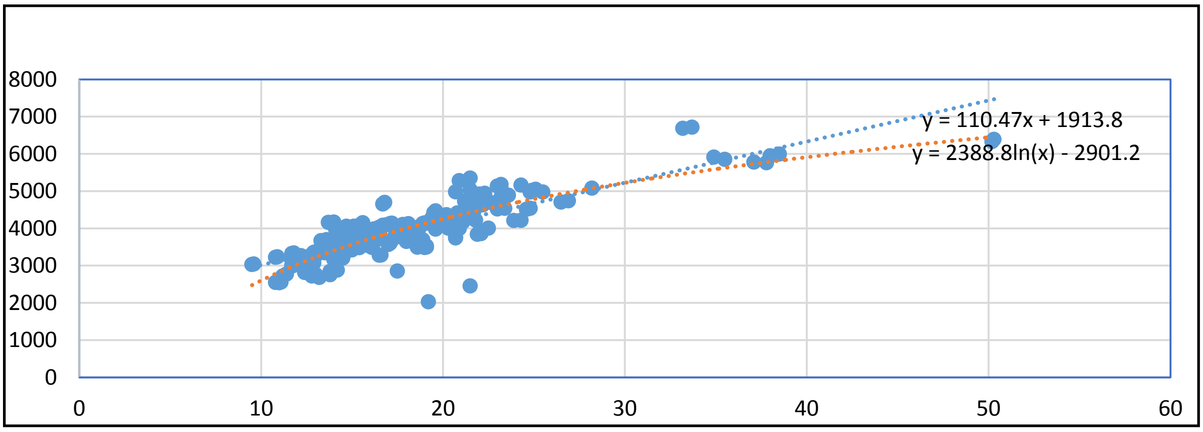
Analysis of the elasticity modulus function relative to the compressive strength based on the lifetime of the concrete is provided on the basis of the method of drawing and calculation of the regression line and the exponential enveloping curve for the results as follows:



(a) The regression line and the strength- elasticity modulus envelope curve of the 11-day age



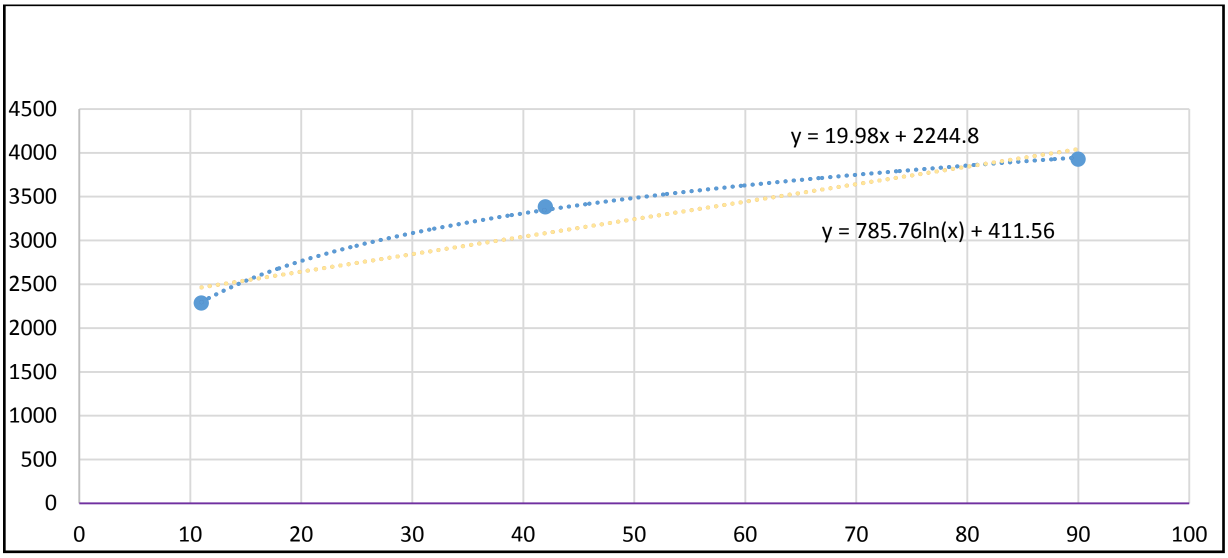
(b) The regression line and the strength- elasticity modulus envelope curve of the 42-day age



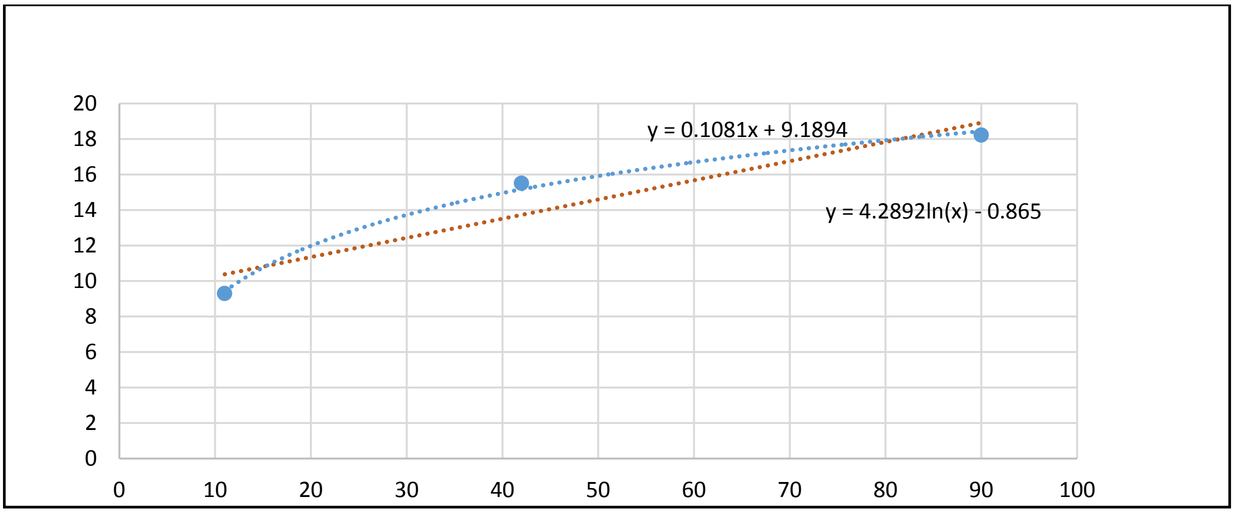
(c) The regression line and the strength- elasticity modulus envelope curve of the 90-day age elastic

Fig. 7. The regression lines and the compressive strength- elasticity modulus envelope curves

Analysis of the elasticity modulus function in relation to time, as well as compressive strength function in relation to time, is presented by drawing and calculating the regression line and the exponential enveloping curve for the results as follows:



(a) The regression line and the time- elasticity modulus envelope curve



(b) The regression line and the time- compressive strength envelope curve

Fig. 8. The regression lines and the time-compressive strength and time-elasticity modulus envelope curves

6.Discussion

There is usually a great deal between the time of construction of the wall of the clay and the time of the operation of the dam, and the determination of the behavioral parameters of the plastic concrete is very important in the operation.
In line with most works, (e. g., ICOLD [4]) figure 18, it has been revealed that strength of plastic concrete increases linearly over time, and even after 1000 days, its strength is increasing linearly. And also similarly in a research (Abbaslou et al. [2]), the below results are presented.

Between compressive strength of 7 days and compressive strength of 28 and 90 days, according to the regression coefficient, more than 0.95 linear relations dominate. The results show a linear relationship between the 28-day tensile strength and the 90-day tensile strength, with regression coefficients greater than 0.98. Using exponential functions, one can find a relation with the values of the regression coefficient greater than 0.98 for converting the compressive strength of 28 days and 90 days to their equivalent tensile strengths. It is clear from the above results that considering such a characteristic of plastic concrete, it can be very important to estimate the strength of the concrete over time.

In contrast to other works (e. g., Abbaslou, et al. [1]; Abbaslou, et al. [2]; Aman, et al. [3]; Falaki [17]; Gholipour [15]; ICOLD [4]; Kazemian, et al [14]; Pashazadeh [5]) the present paper revealed relationships for strength and modulus of elasticity in older ages. In this research, it was tried to provide empirical relations based on what happened at the implementation stage, so that it can be used in a practical work.

7.Conclusions

The following results can be deduced from the above diagrams:
Increase in the strength and elasticity modulus of the plastic concrete after the 90-day life of the concrete has continued significantly (more than 2 times) in accordance with the abacus (Fig-18) presented in the B51 Bulletin of ICOLD letter.
The elastic modulus of growth rate due to the increase in the time duration is lower than the growth of the compressive strength, and, in other words, the plasticity of the concrete is less changed over time.
Considering that nowadays due to various reasons such as on timely support financing of projects and the time consumption of the project's embankment operations, this project is about 5 years after the construction of the cut-off wall (about 2000 days later than the average run time of the cut-off wall) according to the exponential curve of the strength-time chart, the prediction value is as follows:

$$\sigma = 4.289\ln(2000)\text{-}0865$$

$$\sigma = 31.73\, {}^{kg}/_{cm^2}$$

According to the elastic modulus-strength enveloping curve of 90 days, the modulus prediction value for 31.73 kg strength can be calculated as follows:

$$E = 2388.8\ln(31.73)\text{-}2901.2\, {}^{kg}/_{cm^2}$$

$$E = 5357.5\, {}^{kg}/_{cm^2}$$

On the other hand, the value of the elastic modulus can be calculated according to the module-time enveloping curve formula for 2000 days as follows:

$$E = \frac{785}{86\ln(2000)} + 411.56\, {}^{kg}/_{cm^2}$$

$$E = 6384.04\, {}^{kg}/_{cm^2}$$

According to the descriptions at the beginning of the discussion, the regression line based on the effect of independent and dependent variables on predicting the value of the function and the probability distribution with two different methods, the results of calculating the elastic modulus are predictable for 2000 days with a minimum of 5,357 and a maximum of 6,384 kg / m 2.Due to the fact that in analyzes designers usually treated plastic concrete according to conventional concrete, and also with regard to the matters mentioned in the previous paragraphs, in the conclusion plastic concrete behavior is completely different from conventional concrete and the relations mentioned in the above paragraph can be very important and used in analyzes for the correct behavior of plastic concrete.

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