ISSN:1306-3111
e-Journal of New World Sciences Academy
2006, Volume: 1, Number: 1
Article Number: A0001

NATURAL AND APPLIED SCIENCES
ENGLISH (Abstract: TURKISH)
Received: September 2005
Accepted: January 2006

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THE CALCULATION METHODS OF COMPOUND OF CONCRETE AND A NOVEL CALCULATION METHOD

ABSTRACT

In this study, basic information about fundamental calculations of some compound of concrete are given, on the other hand, calculating method of compound of novel concrete named as AYCE is introduced. Besides of calculating among AYCE method and ACI 211, and TS 802 calculating method, the results of experiment obtained from compound of concrete with same properties is submitted comparatively. The values of load per unit area obtained the calculating method AYCE is very near to the values obtained ACI 211 method, the mentioned values become higher than the values obtained the method TS 802. Moreover, the method AYCE is more practical, compared with the method TS 802.
Keywords: Mixture Proportioning, Concrete, Cement, Aggregate, Calculation Methods

BETON KARIŞIM HESAPLARI VE ÖNERİLEN YENİ BİR BETON KARIŞIM HESABI

ÖZET

Bu çalışmada; bazı beton karışım hesaplarının genel esasları hakkında kısa bilgiler verilmekte, diğer taraftan yeni geliştirilen AYCE beton bileşimlerinin hesap yöntemi tanıtılmaktadır. AYCE yönteminin ACI 211 ve TS 802 beton karışım hesaplarıyla karşılaştırılmasının yanı sıra aynı özelliklere sahip beton bileşim malzemeleriyle üretilen betonlardan elde edilen deney sonuçları karşılaştırmalı olarak sunulmaktadır. AYCE hesap yöntemi ile ACI 211'e çok yakın, TS 802'ye göre de daha yüksek basınç dayanım sonuçları elde edilebilmektedir. Ayrıca, AYCE hesap yöntemi TS 802'ye göre çok daha pratiktir.
Anahtar Kelimeler: Karışım Özellikleri, Beton, Çimento, Agrega, Karışım Hesapları

1. INTRODUCTION (GİRİŞ)

Concrete with a general expression, is a construction material which happens at the result of mixing materials such as sand and gravel with water and cement that is adhered them each other at the different ratios. Workability, density, strength, thermal characteristics, modulus of elasticity and environment conditions can be showed as concrete parameters. The matter of using or existence at which ratios of materials which forms concrete can be determined with just the analytical methods. At the present time, there are a lot of methods which have been used for calculation of concrete composition. In our country, TS 802 gives calculation methods of concrete compositions [1, 2 and 3]. It can be said that, this standard is the same as used in U.S.A. At the numerical values, local material isn't taken into account. But, this helps to prepare the first trial mix.

Some of the methods and their main principles are such as;

- "Ideal Granulometry Method" of Fuller.
- "Composite Method" of Feret.
- Aggregate Surfaces Method of Edwards and Young.
- Fineness Method of Abrams.
- Grout Holes Method of Talbot and Richard.
- Ideal Granulometry Method of Bolomey.
- Ideal Granulometry Regions Method of Graf.
- Ideal Granulometry Method of Faury.
- Discontinuous Granulometry Method of Willy and Wallet.
- Portland Cement Association Method "PCA",
- Sweden Method.
- Building Research Establishment Method "BRE".
- American Concrete Institute Method "ACI", etc,

The methods given above and proposed AYCE method are insufficient to calculate the desirable qualified concrete in once. These are the origin points to find out composition ratios. Exact values must be determined by experiments. Because the basis at the concrete compositions, is the determination of most economic and most useful aggregate, cement, water and additives if needed, so that these are able to form a composition which has desired characteristics after hardened and has ability of workability at the desired level. Determination of all these factors at the desired level is possible by making serial experiments and necessary corrections [3]. In the calculation of the concrete compositions, the aimed and most noticed points are suitable workability, sufficient strength, resistance to environment conditions, special conditions (lightness, tensile stress, minimum shrinkage, earthquake region concrete. etc.) and economical.
In the calculation of composition of the concrete [4 and 5],

- The sizes of the building member in which concrete will be used, chemical effects which the member will subject to, external effects such as freezing-decomposition, impact, wetting-desiccation, abrasion and characteristics which the member must have such as impermeability, workability, volume stability and image are taken into consideration.
- Grain size and dispersion of aggregate, water/cement ratio, the amounts of cement, air and additive material are taken from table or found out by calculation.
- Testing of specimens prepared suitable to mixture that is obtained by calculation, if there is a difference between the result of experiment and calculation, calculation will be corrected according to difference and finished.

"The compasity of concrete" term means the total of real volumes of solid materials as a dimension of m^3 such as cement, sand and coarse aggregate in 1 m^3 concrete. As a general rule, it is suggested that composite value should not be less than Λ= 0.80 in a concrete that has normal characteristics [2, 5, 6 and 7]. In order to increase the compasity in a concrete, puzzolanic additive materials can be used. However the cement and additive materials are fine, so these will be able to fill in holes. Consequently compasity increases.

2. RESEARCH SIGNIFICANCE (ARAŞTIRMANIN ÖNEMİ)

Quality concrete is desired to have some certain properties. One of them is the composition of the constituents per cubic meter besides their physical and mechanical properties. Thus the calculation of mixture is very important for the quality of concrete. There are various methods in calculation of the composition or the rates of the constituents in concrete, each of which presents different approaches. Among them, AYCE method differs from the others in giving water/cement ratio with respect to compression strength, amount of collapse and maximum aggregate size. The method is a unique practical one in this sense. The amount of mixing water is also given by desired collapse height, aggregate size and calculated water/cement ratio. As known mixing water AYCE method has a big effect on the strength of concrete. AYCE was developed since desired compression strength, maximum aggregate size and collapse height should be considered in determining water/cement ratio and amount of mixing water.

3. ANALYTIC STUDY (ANALİTİK ÇALIŞMA)

About 70-75% of the concrete is aggregate by volume. In the production of concrete, in order to adhering the aggregate grains to the cement, all the surfaces of the grains have to wet with a thin water layer. As the grain sizes decrease, total surface will increase. Although total surface increases, required water amount for wetting the grains will also increase. After hardening of concrete, wetting water will evaporate and the holes will exist. Because, this water is more than the required water for hydration of cement and for jell water in the hardened cement jell, so doesn't bond to cement. The holes that is formed due to this extra water, effect the strength and resistance of the concrete negatively. On the other hand, the holes between grains depend on of granulometry [2 and 5].

In a situation of existing a definite function between grain sizes, it is possible to reduce the voids of deposit to minimum. Being minimum of deposit voids will cause to decreasing of using of cement and water, so, it will be possible to produce more economic and high strength concrete. At the result of the experiments which were made on this ground, ideal gradation or reference granulometry graphs were found. From the point of view of convenience in practice, this graphs which enter on standards of many countries, are presented as regions bounded by curves, instead of just curves.

The aim of the ideal granulometry is to obtain an aggregate mixture that has minimum total surfaces and has minimum holes at realizable ratio. Generally the aggregates in nature don't conform to this ideal gradation while they are at raw situation. The problem is to obtain a mixture which has a nearest gradation to the ideal granulometry by means of mixing these natural aggregates at determined ratios [5].

The most important composition parameter that effects the strength and resistance quality of concrete is water/cement ratio. That is, this is a ratio of cement weight to water weight that is put into 1 m^3 concrete mixture.

The water that is put into concrete has three important functions. First one is to supply hydration of cement, second one is to wet the aggregate surfaces, third one is to increase the workability to desired level. On the other hand, it is known that water in excess of requirement in mixture causes to decrease the strength and resistance of the concrete. In 1 m^3 concrete, as the cement amount is C (kg) and total weight of aggregate is A (kg), mixture water amount can be calculated as a following expression;

$$W = \alpha C + \beta A \tag{1}$$

Where, first term (αC) is the amount of the required water for hydration of the cement. The second term (βA) is the amount of the required water for wetting all the aggregate grains that consist of the coarse aggregate and sand. In this term, the coefficient β that is called as water coefficient is valued depending on grade of desired workability characteristic, the shape of the aggregate grains and granulometric composition of aggregate.

For rising workability property of concrete to desired level and for soaking aggregate surfaces, required water amount is calculated by means of Bolomey equation. In the mixture water amount equation that is used in AYCE Method the coefficient as 128 is a value which is arised relating to water amount that raises cement hydration, wetting water and workability of concrete which are calculated according to "A", "B", and "C" curves that are given in TS 706 [8]. That is, this coefficient is valid whatever maximum aggregate size exists. In the case of discontinuous granulometry, it can give good results too.

For bonding of aggregate to the cement mortar and for moving aggregate grains in viscose paste environment, wetting and surrounding with a very thin water layer of grain surfaces are needed. A part of wetting water will be lost after concrete hardens; air will take its place. That's why, remaining at minimum level of wetting water of aggregate is ideal. Aggregate properties that determine wetting water of aggregate are actual water content and fineness of aggregate. These are; exactly dry, surface of grains is dry but interior is waterlogged (saturated surface dry surface=SSD), surface is wet and waterlogged. The most ideal case among them; surface is dry but interior of grains is waterlogged; so, this is medium case. In this case, aggregate doesn't absorb the water of cement paste, wetting water is sufficient just to be thin water layer on the surface. The other two cases devoid of possibility of control. There are standard experiments for fixing of SSD. The aggregates that has relative humidity of over 50 percent and are stored in closed environment may suppose in SSD case. Essentially, all aggregate tests are done on aggregates which are in SSD case.

There are suggested theoretical equations to form a water layer with sufficient thickness on aggregate grains. Bolomey equation which is the one of them, together with not having any value practically in order to explain the event is given as below. To soak a definite aggregate deposit, required water amount "e" is calculated as,

$$e = \frac{N.q}{\sqrt[3]{d1.d2}} \tag{2}$$

In which; "d_1" and "d_2" are sieve sizes (mm) respectively, "q", the weight of material (kg), which remains among two sieves, "N" is a coefficient according to desired slump of concrete and to aggregate type. As it will be recognized from the Bolomey equation, if fine aggregate is more, wetting water will be more. Adding water to crushed stone is more than adding water to round aggregate. Practically, it can be said that, wetting water at gravels is between 1 and 2 percent of its weight and at sands is between 5 and percent of its weight.

The other equation used in calculation of wetting water is fineness modulus-water equation. According to used TS706 sieve sets for now, fineness modulus of aggregate "k" is calculated. Required water for wetting aggregate deposit is calculated by a simple equation as,

$$E = \alpha(10 - k) \tag{3}$$

However is a coefficient that depends on kind of aggregate and slump of concrete.

This equation, as Bolomey equation, proves that angular aggregates need more water. Furthermore, this equation gives total water demand of concrete including cement. The values obtained from this equation are theoretical. How slump concrete owns can not be understood unless being produced.

In AYCE method, in developed equation for water/binder (W/B) ratio, D_{max} was taken into consideration and a coefficient that gives wetting water approximately was developed according to D_{max}. Thus, W/B ratio of concrete to be produced was based on aimed f_{cm} and D_{max}. That is, when D_{max} increases, mixing water amount decreases. Calculated water amount according to results of exemplary problem, is more than required water amount for hydration and wetting. It is understood that this excessive water can be sufficient for desired slump amount in slump tests which are done.

There are also tests which explain mixing water amount depends on fineness modulus. Some of them as follow [6]:

Equation which is suggested by Palotos;

$$W = 0{,}15C + 28(11 - k) \tag{4}$$

Equation suggested by Popovic

$$W = C\left\{0{,}06 + \frac{0{,}019\left[(2k-60)2 + 6570\right]}{C - 100}\right\} \tag{5}$$

In concrete composition methods, for achieving composite relation, over 200 exemplary problems are developed and results which are arised by advanced tables and equations are evaluated completely in mentioned methods. On this occasion, according to basis of calculations of concrete compositions which is called as ACI 211. The composite as Λ=0.807, at TS 802, Λ=0.828, and at AYCE method, composite ratio which depends on f_{cm} varies continuously. That is, in concrete which has a f_{cm} of 16, Λ=0.805; however in concrete which has f_{cm} of 50, Λ=0.820 (Table 3).

According to TS 802 and ACI 211 "Basis of calculation of concrete composition" the amount of materials which form 1 m^3 concrete, W/C and composite ratios are summarized at Table 1, 2 and 3. Physical properties of materials and aimed characteristics are such as:

- f_{cm} =30 MPa, D_{max} =31.5 mm, Slump =80 mm.
- Specific Gravity of Cement =3.10 g/cm^3 (Elazığ CEM I)
- Compressed air (estimated) =1%
- Climate and service conditions are not hard
- 40% of fine aggregate, and 60% of cyclopean aggregate
- Using of Elazığ-Palu aggregate
- Using Elazig city water as concrete mixing water
- Specific gravity of cyclopean aggregate =2.74 g/cm^3
- Water absorption capacity of cyclopean aggregate =80%,
- Existing moisture =0.46%
- Specific gravity of sand mixed =1760 kg/m^3,

- Existing moisture =0.73%
- Specific gravity of sand =2.63 g/cm^3 (SSD sp. gravity=2.65 g/cm^3)
- Fineness modulus =3.32

At the condition of using of materials which their physical and other characteristic properties are given above, W/C ratio which will be obtained, mixing water, cement, fine, and cyclopean aggregate amounts are summarized at Table 1, 2, and 3.

Table 1. According to basis of ACI 211, the amount of materials which are mixed to 1 m^3 concrete composition, W/C, and composite ratios (Tablo 1. ACI 211 esaslarına göre 1 m^3 betonun birleşimine giren malzeme miktarı, S/Ç ve doluluk oranları)

Class of Concrete f_{cm}(N/mm^2)	W/C	Mixing Water (kg)	Cement (kg)	Fine Aggregate (kg)	Coarse Aggregate (kg)	Composite Ratio
16	0.78	182	235	883	1086	0.807
20	0.67	182	270	853	1086	0.807
25	0.58	182	312	818	1086	0.807
30	0.52	182	350	785	1086	0.807
35	0.47	182	386	755	1086	0.807
40	0.43	182	421	726	1086	0.807
45	0.40	182	454	698	1086	0.807
50	0.38	182	485	671	1086	0.807

Table 2. According to basis of TS 802, the amount of materials which are mixed to 1 m^3 concrete composition, W/C, and composite ratios (Tablo 2. TS 802 esaslarına göre 1 m^3 betonun birleşimine giren malzeme miktarı, S/Ç ve doluluk oranları)

Class of Concrete f_{cm}(N/mm^2)	W/C	Mixing Water (kg)	Cement (kg)	Fine Aggregate (kg)	Coarse Aggregate (kg)	Composite Ratio
16	0.78	162	208	801	1251	0.828
20	0.70	162	231	793	1239	0.828
25	0.62	162	261	782	1223	0.828
30	0.55	162	295	771	1205	0.828
35	0.48	162	338	757	1182	0.828
40	0.43	162	378	743	1161	0.828
45	0.38	162	426	726	1135	0.828
50	0.33	162	491	704	1101	0.828

Table 3. According to basis of AYCE, the amount of materials which are mixed to 1 m^3 concrete composition, W/C, and composite ratios (Tablo 3. AYCE esaslarına göre 1 m^3 betonun birleşimine giren malzeme miktarı, S/Ç ve doluluk oranları)

Class of Concrete f_{cm}(N/mm^2)	W/C	Mixing Water (kg)	Cement (kg)	Fine Aggregate (kg)	Coarse Aggregate (kg)	Composite Ratio
16	0.75	185	246	763	1192	0.805
20	0.66	182	276	756	1181	0.808
25	0.58	179	311	747	1168	0.811
30	0.52	176	342	739	1155	0.813
35	0.47	174	371	731	1143	0.815
40	0.43	172	398	724	1131	0.817
45	0.40	171	424	717	1120	0.819
50	0.38	170	448	710	1120	0.820

AYCE method which is developed for calculations of concrete compositions makes good use of a lot of equations. These equations briefly such as;
Equation 1. Gives D_{max} which was determined ahead, slump and W/C ratio according to f_{cm} value.
Equation 2. Gives slump which was determined ahead and mixing water amount according to D_{max}.
Equation 3. Gives mixing water and cement amount according to W/C ratio.
Equation 4. Gives the amount of fine and coarse aggregate according to basis of volume.

Equation 1:

$$\frac{W}{C} = \left(\frac{128(Slump)^{0.1}}{fcm\,(D\max)^{0.2}}\right)^{0.6} \tag{6}$$

In this equation f_{cm} = compressive strength of concrete at 28 days (MPa or N/mm^2) Slump= the amount of slump of fresh concrete which is obtained in slump cone test (mm) and D_{max}= maximum grain diameter of aggregate (mm).

Note: For obtaining better results, it is suggested that W/C ratio must be determined with three orders after comma.

Equation 2:

$$Wwater = \frac{128\,(Slump)^{0,1}\,(W/C)^{0,123}}{(D\max)^{0,01}} \tag{7}$$

In this equation; slump= the amount of slump which was determined ahead (mm). W/C= the ratio which was found at equation 1 and D_{max}= maximum grain diameter of aggregate (mm).

Equation 3:

$$Wcement = \frac{Wwater}{W/C} \tag{8}$$

In this equation; W_{water} = the amount of water which was found at equation 2 (kg/lt), W/C= the ratio which was found at equation 1.

Equation 4 :

$$Wagg = 1000 - \left(\frac{Wcement}{\delta cement} + \frac{Wwater}{\delta water} + Airvoid\right) \tag{9}$$

- W_1= V_{Agr} * Fine aggregate ratio (%) * δ fine agg.
- W_2= V_{Agr} * coarse aggregate ratio (%) * δ coarse agg.
- W_3= V_{Agr} * crushed stone ratio (%) * δ crushed stone.

  In this equation;
- V_{Agr}= Volume of total aggregate mass (cm^3)
- W_{Cement} = Cement weight which was found at equation 3 (kg)
- W_{Water} = The amount which was found at equation 2 (kg/lt),
- W_1= Fine aggregate*desired ratio to be exist in concrete(as 0.30)
- W_2= Coarse aggregate*desired ratio to be exist in concrete(as 0.40)
- W_3= Crushed stone*desired ratio to be exist in concrete(as 0.30)
- cement= Specific gravity of cement(g/cm^3)
- Fine agg.= Specific gravity of fine aggregate (g/cm^3)

- Coarse agg.= Specific gravity of coarse aggregate (g/cm^3)
- Crushed stone= Specific gravity of crushed stone (g/cm^3)
- Air void= the volume of air

The results which were obtained at tables 1, 2, and 3 are the mixture ratios of aggregates in dry state. Calculation of additional water amount is required to supply workability and aimed slump amount in concrete. The additional water amount, to be scaled weights of aggregates according to daily moisture case and also to be scaled weights of mixture at the bases of net water+saturated surface dry aggregate and gross water+dry aggregate should be calculated with respect to basis of ACI 211.

Equations which are proposed for additional water amount in ACI 211 must be used and are given as below;

Additional water amount

For fine aggregate ……

W_1 (water absorption capacity-existing humidity) =….. kg

For coarse aggregate ……

W_2 (water absorption capacity-existing humidity) =….. kg

To be scaled weights

Water = W_w+water amount for coarse aggregate+water amount for fine aggregate)=…. kg

Cement = W_c

Fine aggregate = W_1*(existing humidity) =………kg

Coarse aggregate = W_2*(existing humidity) =………kg

With respect to basis of net water+saturated dry surface aggregate

Water

Cement

Fine aggregate = W_1*(water absorption capacity) =…….kg

Coarse aggregate = W_2*(water absorption capacity) =…….kg

Calculation of additional water amount

For coarse aggregate = coarse aggregate (water absorption capacity-existing humidity)=…. kg

For fine aggregate = fine aggregate (water absorption capacity-existing humidity)=…. kg

4. EXPERIMENTAL WORKING (DENEYSEL ÇALIŞMA)

Before going through experimental working, values which were obtained from "example belongs to calculation of mixture" that was presented in TS 802, page 13-16 were presented at table 4 by the way of using every three method. At this example, for a column which has a shortest dimension 26 cm, concrete cover 35 mm and may be subject to freezing-decomposition frequently; mixture computing of f_{cm}=25 MPa concrete which will be made without using air-entraining admixture is desired that the working conditions of site in where concrete will be made is not known. Used materials are such as;

Cement: CEM I 32.5 (=3.15 kg/dm^3)

Aggregate: Granulometry of natural mixed aggregate that were taken from oven of aggregate is given at table 5. Grain shape and water absorption ratio for every grain class are the approximately same (water abroption ratio = 0.5%). Density: 2.8 kg/dm^3 (saturated surface dry)" [8].

In addition to problem data in TS 802, the slump amount: 70 mm., D_{max}: 32 mm., Fineness modulus: 3.3, 2,8 kg/dm^3 as a specific gravities of fine and coarse aggregate, average cylinder compressive strength (f_{cm})= 31 N/mm^2 and: 1% as amount of air voids are taken. Composition amounts of sample problem which are taken into consideration and distributions according to methods in order to compare the experimental working results are summarized at Table 4.

Compressive strengths of hardened concretes which were obtained by means of Table 4 data were obtained according to basis of TS 3114 and arithmetical averages of results also were given at Table 7 as N/mm^2, physical and chemical properties of aggregates and cement which we used in tests were also given in Table 5 and 6.

The aim in forming of Table 4, according to an example problem, is achieving how ACI 211, TS 802 and AYCE methods give results whether analytically or experimentally. As to be understood from the data of Table 4 and Table 7, it was not met with an abnormal result. At the light of this positive progress, according to data of Table 1, 2, and 3, new concrete specimens was produced and concrete-strength test results of concretes at 28 and 56 days were again taken. These final results of general aimed tests are also summarized at Table 8.

Table 4. Comparing of TS 802, ACI 211, and AYCE methods with respect to concrete composition ratios
(Tablo 4. TS 802, ACI 211 ve AYCE yöntemlerinin beton birleşim oranları açısından karşılaştırılması)

Compared Criterions	TS 802	ACI 211	AYCE
W/C Ratio	0.53	0.51	0.50
Water Weight(kg)	160	179	173
Water Volume (dm^3)	160	179	173
Weight of Cement (kg)	302	352	346
Volume of Cement (dm^3)	95.87	111.74	109.84
Weight of Coarse Aggregate (kg)	1233	1089	1186
Volume of Coarse Aggregate (dm^3)	440.35	388.92	423.57
Weight of Fine Aggregate (kg)	822	868	790
Volume of Fine Aggregate (dm^3)	293.57	310	282.14
Air Void (dm^3)	10	10	10
TOTAL .... Weight (kg) .... Volume (dm^3)	2517 999.79	2488 999.66	2495 998.55

The general principles of compressive strength test are briefly as follows; mixture ratios of concretes which were prepared for compressive strength test were taken from Table 1, 2, 3, and 4. Prepared fresh concrete according to basis of TS 3114 was compacted by vibrating to the molds and it was prevented in curing room that has a $23\pm2^{o}C$ temperature under 90% relative humidity to put into water tank.

After it was waited for a day here, it was taken into water tank that has a stable temperature of 23 ± 2 ^{o}C. These mixtures were waited until test day at this environment [10 and 11].

Table 5. Physical properties of aggregate used in tests
(Tablo 5. Deneylerde kullanılan agreganın fiziksel özellikleri)

Class of Aggregate Grain	Unit Weight (Dense) (kg/m^3)	Spesific Gravity (SSD) (g/cm^3)	Water Absorption (%)	Existing Humidity (%)	Abrasion (%)	
0-4.0 mm	1760	2.63	1.11	0.73	100cycle	500cycle
4.0-30.5 mm	1719	2.74	0.80	0.46	6.98	18.63

Table 6. Physical and chemical properties of cement used in tests
(Tablo 6. Deneylerde kullanılan çimentonun fiziksel ve kimyasal özellikleri)

Chemical Composition (%)	
SiO_2	20.46
Al_2O_3	5.45
Fe_2O_3	3.15
CaO	63.13
MgO	2.96
SO_3	2.40
Heater Loss	1.54
Not to Determined	0.73
Insoluble Residue	0.26
Physical Properties	
Specific Gravity (gr/cm^3)	3.10
Specific Surface (m^2/kg)	3493

Table 7. Compressive strength results of concrete specimens at 7 days and at 28 days which are prepared according to sample problem in TS 802 (N/mm^2)
(Tablo 7. TS 802'deki örnek probleme göre hazırlanan beton numunelerinin 28 ve 56 günlük basınç dayanım sonuçları (N/mm^2)

Class of Concrete f_{cm}	ACI 211		TS 802		AYCE	
	At 28 Days	At 56 Days	At 28 Days	At 56 Days	At 28 Days	At 56 Days
31	41.4	47.1	40.7	45.9	41.0	46.3

Table 8. Compressive strength results of concrete specimens at 7 days and at 28 days which are prepared according to general basis of ACI211, TS802, and AYCE (N/mm^2)
(Tablo 8. ACI 211, TS 802 ve AYCE genel esaslarına göre hazırlanan beton numunelerinin 28 ve 56 günlük basınç dayanım sonuçları (N/mm^2)

Class of Concrete f_{cm}	ACI 211		TS 802		AYCE	
	At 28 Days	At 56 Days	At 28 Days	At 56 Days	At 28 Days	At 56 Days
16	22.6	25.0	20.7	21.0	23.0	26.8
20	29.0	32.3	29.5	32.0	29.5	33.6
25	33.5	37.0	32.6	36.1	34.0	36.8
30	41.5	46.0	39.8	46.3	41.0	44.5
35	47.0	52.5	47.3	52.4	47.0	52.1
40	53.0	58.5	51.9	57.5	52.8	59.4
45	63.5	70.3	62.4	69.5	64.0	71.1
50	71.0	79.6	69.1	76.5	69.5	75.7

5. CONCLUSION AND SUGGESTIONS (SONUÇ VE ÖNERİLER)

When Tables 1, 2, and 3 obtained at the result of analytical study are investigated, this matter can be advanced;

- At ACI 211 method, mixing water and coarse aggregate amount are constant, the others are variable. That is, if it is desired from a sample mixture to have much more strength, it will be talked about increment on cement amount and decreasing in fine aggregate amount. However composite remains at the same level.
- At TS 802, mixing water amount is constant, the others are variable. In a sample mixture which is desired to have more strength, it is talked about decreasing in aggregate amount and increment in cement amount. That is, as the phase of cement is

increased, phase of aggregate decreases. However, composite ratio remains at the same level.

- At AYCE method, whole concrete components are variable. That is, as it is desired from a sample mixture to have more strength, it is talked about decreasing in mixing water amount and aggregate amount, but increment in cement amount. Together with decreasing water amount, composite ratio is able to have higher value in comparison with the other methods.
- The lowest coarse aggregate amount which was obtained by this method is more than the amounts which were obtained by ACI 211 and TS 802 methods. That is, it can be say that, aggregate of this method is higher than aggregate phases of ACI 211 and TS 802 methods.
- In sample concrete classes which was given in AYCE method. Composite chanced between 0.805 and 0.820. However in other methods, it remained in same levels. Furthermore, at each three methods of mixture, W/C ratios are very close to each other.

As the Table 4 was investigated, this matter may be advanced.

- Between used methods in this study, the lowest w/c ratio was obtained as 0.50 by AYCE method.
- From the point of amount, mixing water and cement are less than ACI 211, but more than TS 802.
- Each three method, as a matter of total weights, AYCE remains higher than ACI 211, but lower than TS 802. Total volumes are the same as each other.

As the Table 7 that were obtained at the result of experimental study are investigated, this matters may be advanced;

- The lowest compression strength value among prepared concretes according to sample problem in TS 802 is obtained from prepared concretes according to basis of TS 802 yet. If the mixture calculation is done according to AYCE method, much more strength will be obtained.

As the Table 8 is investigated at the result of general experimental study, this matter may be offered;

- At the general mean, suggested AYCE concrete mixture computing method gives similar values in point of w/c ratio with respect to ACI 211 and TS 802.
- It can be said that, concretes which are prepared by using AYCE computing method are generally better than TS 802 as a matter of compressive strength results.

Consequently, it can be said that, as is understood from above table data, AYCE concrete mixture computing method is much more convenient according to TS 802 from the availability point of view. On the other hand, compressive strength values of concretes which are obtained at the same materials and environment conditions are generally higher than TS 802, but are close to each other according to basis of ACI 211.

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