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Effects of Workmanship Values on Cost of Transportation Structures for Different Concrete Classes

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Abstract: *Art structures are the integral parts of transportation structures. Art structures were built as reinforced concrete (RC) generally. In this study, three different structures which were RC bridge, culverts and retaining walls were selected. The amount of concrete used in each of these structures was calculated based on the quantity of materials. Cost calculations for each art structure were made for different concrete classes. The aim of this study was to determine the effect of concrete class on the cost of art structures in transportation structures. Calculations have been made for each concrete class which was selected as C20, C25, C30, C35, C40 and C45. In this study, workmanship values for concrete related manufacturing from the Ministry of Environment and Urban Planning, and implementation period of the construction companies during the construction was obtained, organized and compared separately for selected art structures.*
Keywords: *Bitlis, Ahlat, rapid assessment, RC*

I. Introduction

In general meaning, works of art means for all of works such as sustaining and revetment walls which are made to restrict sizes of excavation and embankment slopes due to any reasons with hydraulic structures such as concrete pipe, culvert and bridge which are made in order to protect transportation structures [1, 2].

Works of art constitute a great important part of transportation structures. Sustaining wall is the application of culvert and bridge transportation structure (Figure 1.1).

Fig1. Various art structures

Generally, works of art are made as concrete and reinforced concrete. Concrete is the main of factors which would affect on the cost for concrete and reinforced concrete.

Reinforced concrete (RC) is a building material which is obtained by being combined of steel and concrete and which is used in common. Loads on the structure are met by the use of concrete's pressure strength and steel's tensile strength together. Adherence between concrete and steel will increase adherence of reinforced concrete [3].

Two main functions which are expected from a well construction engineer are that he designs and applies safety and economical structures. The reason that reinforced concrete - type structure occur is that concrete has a feature of pressure strength and it is much more economical than steel. That reinforced concretes' concrete is economical is based on a few factors. Parameter which is considered on this study is reinforced concrete pressure strength (f_{ck}). For this purpose, reinforced concrete works of art that their building ends have been chosen.

On this study, sustaining wall, culvert and bridge have been taken as sample for work of art. Amounts of concrete used to form Bill of quantities have been calculated separately for each work of art.

For amounts of concrete which have been calculated, the effect of change in concrete classes on building cost have been tried to be revealed. In this sense, cost calculations have been made in consideration with C20, C25, C30, C35, C40 and C45 concrete classes and the results which have been obtained have been

compared. In the case that each work of art is made in different concrete class, real cost variance has been revealed.

II. Methodology

The thing which is expected from a construction engineer is that the structure is to economical as providing efficient safety level. Concrete strength on concrete and reinforced concrete - type structures affairs directly on both safety and cost. It is known that concrete strength is one of contributing factors on structural analyses. Concrete strength on concrete and reinforced concrete - type structures affects directly on structural analyses. Concrete classes are made by pressure strengths, using cube and cylinder samples. Classification by characteristic cylinder pressure strength has been showed at Table 1.

Table1. The classification of concretes [4]

Concrete Class	C20	C25	C30	C35	C40	C45
f_{ck} (MPa)	20	25	30	35	40	45

If there is an increase on concrete strength, it increases strength on reinforced concrete structures. The problem is that; what will be the effect of concrete strength on structure cost as it is chosen high on design step? Here it is, it has been tried to be calculated about what an effect of concrete strength will be especially on the cost of structure, on this study.

Total cost of a structure: it is defined as a cost which consists of expenses made on all processes including the processes starting with the determination of need, going on during the service life of structure and removing cost by the ending of service life [5]. Before starting to any building, outline specifications are said to work out the cost of structure and approximate cost is said to parameter which is found at the end of specification. Before the preparation of projects or during the first step of project preparation, approximate structure cost can be calculated as some pre-determinations related to total building area of the structure and building quality are made and they are based on some acceptations [6].

Quantities are said to calculate manufacturing amount which is made or built, on works of building and others. Total nominal values of parameters which constitute manufacturing for any manufacturing state unit price for manufacturing. While cost calculation is made for complete works of art, quantities and unit price have been used in the study.

III. The art structures that investigated in this study

On this study, sustaining wall, culvert and bridge which are built as reinforced concrete have been taken as sample. Cost calculation has been made for different concrete classes for each work of art.

III. a. Sustaining Walls

Sustaining Walls (retaining structures) are building elements which meet lateral earth effect which occurs from ground at two different levels by the demanded safety and which protect the balance as preventing that ground gets slopes angle. All precautions which will be taken in order to provide stability of side slops (natural slopes) which are constituted on geological and hydrological facilities and artificial slopes (split, beri and deep excavation) which are constituted for building, in order to provide security and minimize the company expenses (highway, railways , irrigation facilities industry) involve in retaining structure [7, 8]. Type of the structure is cast-in-place reinforced concrete. Space is at 6m, length is at 60m, base slab gauge is at 1.5m height.

Size and cross section of sustaining wall which are considered on this study have been showed at Figure 3.1 and Figure 3.2.

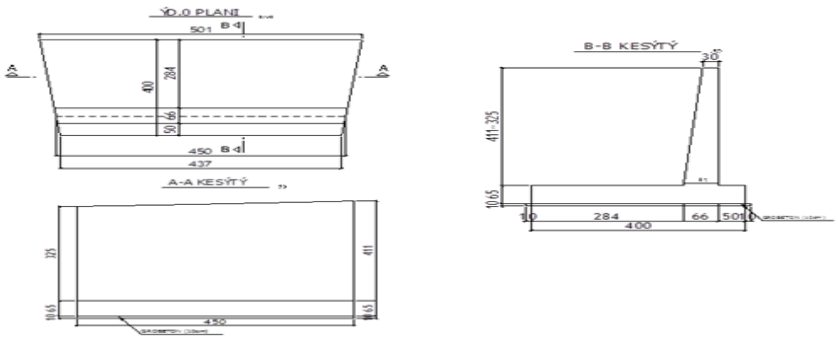

Fig.3. 1.The width section of sustaining wall

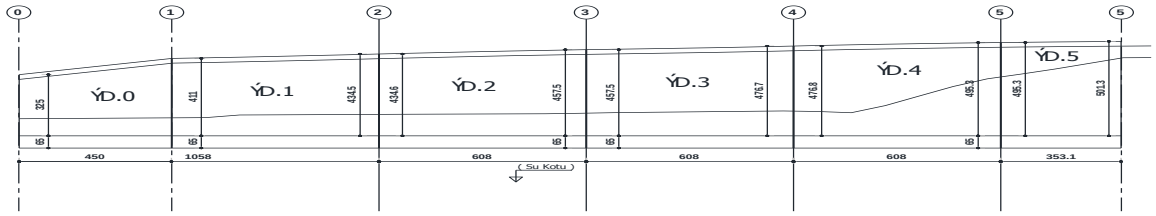

Fig3.2. Length section of sustaining wall which is a basis to the study

On the study, quantities belonging to sustaining wall which is inspected and its building ends have been showed at Table 2.

Table2. Quantities belonging to RC sustaining wall which is examined on the study

Sustaining wall (base slap):	(4,37+5,01)/2x4,00x0,65=12,194m³
Sustaining wall (shear):	(3,25+4,11)/2x4,50x(0,66+0,30)/2=7,949m³
Sustaining wall (base slap):	(5,91 +6,77)/2x4,00x0,65=16,484 m³
Sustaining wall (shear):	(4,11+4,345)/2x6,08x(0,66+0,30)/2=12,338 m³
Sustaining wall (base slap):	(5,91+6,77)/2x4,00x0,65= 16,484m³
Sustaining wall (shear):	(4,346+4,575)/2x6,08x(0,68+0,30)/2=13,289m³
Sustaining wall (base slap):	(5,91+6,81)/2x4,20x0,65=17,363m³
Sustaining wall (shear):	(4,575+4,767)/2x6,08x(0,70+0,30)/2=14,200m³
Sustaining wall (base slap):	(5,91+6,81)/2x4,20x0,65= 17,363m³
Sustaining wall (shear):	(4,768+4,953)/2x6,08x(0,70+0,30)/2=14,776 m³
Sustaining wall (base slap):	(3,43+3,81)/2x3,00x0,65= 7,059m³
Sustaining wall (shear):	(4,953+5,013)/2x3,53x(0,55+0,30)/2=7,476m³
TOTAL = 156.975m³	

III. b. Culvert

Culvert is said to hydraulic works of art used to conduct runnels which are constantly flowing or occur as a result of raining from one of road bisque to its other side [9]. It has been made utilize the flow of surface water to bisque on embankment of road by drainage. Internal dimensions of culvert are at 7.00 width, at 5.00 height, 76.12m length. Diagonal is 50 grad. Maximum embankment height is 4.61m. It has got 7 anoes. That making anol decreases especially iron and pattern costs especially in terms of cost and making it as an ano of culvert at 76.12 heights with these reasons have got a separate importance on resistance which culvert will indicate on road. There are 2 expansion joints, 4 building joints and 2 water retaining bands among anoes. Excavation's ground has been opened at 50 cm width from the main ground. Excavation incline of slope has been accepted as 1/2. Culvert sides above excavation have been unrolled and constrained simultaneously by sand -gravel materials and embankment materials from top elevation to its upper part at 50 cm. The size and cross section of the culvert which have been considered in the study have been showed at Figure 3.3.

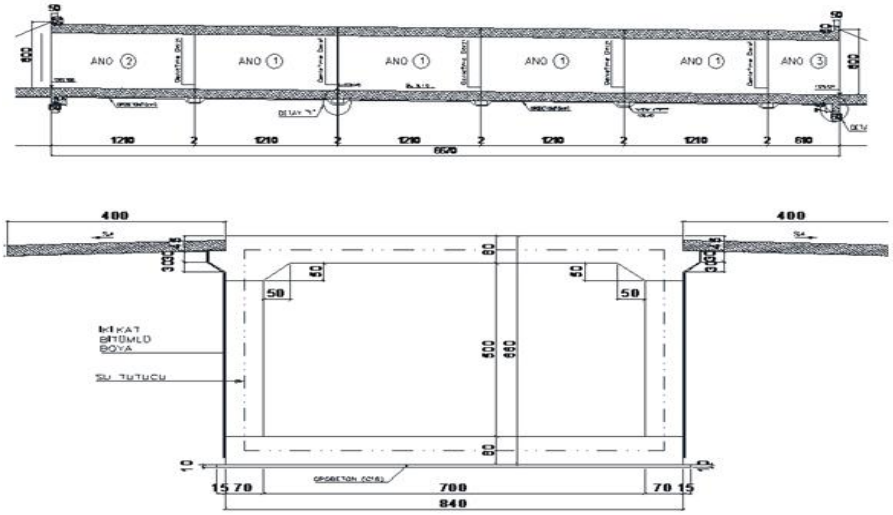

Fig3. 3. Thewidth and length sections of culvert which is considered on the study

Quantities belonging to culvert which it has been examined in the study and its construction has been completed have been showed at Table 3.

Table3. Quantities belonging to RC culvert which is examined on the study

Body base slab concrete: 76.12x10.40x0.90=712.483m³
Body shear concrete : 2x76,12x0,80x5,00=608,960m³
Internal gussets: 2x76.12x(0.50x0.50)/2=19.030m³
Splay concrete: 2x76,12x(0,30+0,60)/2x0,30=20,552m³
Body bridge floor concrete: 76,12x0,80x8,60=523,706m³
Reinforced padstone concrete: 10.40x0.50x0.25x2=2.600m³
Entry and exit kerb concrete : 2x8.60x1.13x0.50=9.718m³
V1-Base slab concrete: 0,75x (10,40x6,20)=48,360m³
V2-Base slab concrete: 0.50x (4.75x5.50)=13.063m³
V3-Base slab concrete: 0,75x (8,20x6,20)=38,130m³
V1-1-Base slab concrete: 0.75x(2.89+3.55)/2x0.36=0.869m³
V3-1-Base slab concrete: 0.75x(2.55x2.55)/2=2.438m³
V1- Body Concrete: 4.65x0.50x (1.00+2.80)/2=4.418m³
V2- Body Concrete: 9,00x0,70x(2,80+6,30)/2=28,665m³
V3- Body Concrete: 10.80 x0.70x (1.00+6.30)/2=27.594m³
V1 Raft concrete: 0,75 x (9,20x 6,20)=42,780m³
V2 Raft concrete: 0.50 x (6.50x 5.50)=17.875m³
V3 Raft concrete: 0,75 x (11,30x6,20)= 52,545m³
V2-1 Raft concrete: 0,75x (2,55x2,55)/ 2=2,438m³
V2-2 Raft concrete: 0.75x(2.89 +3.56)/2x0.36= 0.871m³
V1- Shear Concrete: 11.70x0.70x (1.00+6.30) / 2=29.894m³
V2- Shear Concrete: 10,00x0,70x (3,07+6,30) /2= 32,795m³
V3- Shear Concrete: 6.40x0.50x (3.07+1.00) /2=6.512m³
Approach slab concrete : 1 adx5,00x21,59x0,25= 26,988m³
Approach slab concrete : 1 adx5,00x21,43x0,25=26,788m³
Approach slab concrete : 1 adx5.00x21.71 x0.25=27.138m³
Approach slab concrete : 1 adx5,00x21,55 x0,25=26,938m³
TOTAL = 2354,148m³

III. c. Reinforced Concrete Bridge

They are works of art which are built to provide transportation on places such as bridges, river, another roads and railway and which are larger than 10 meters of a distance between two braces from niches. Subway and basic excavations of entry - exit structures have been opened 25 cm deeper than main base elevation and 25 cm wider than main dimensions, its main base has been filled by 25 cm C14 lean concrete. The incline of slope for base excavations has been accepted as 1 horizontal and 2 vertical (1/2). Back sides of the project on each side of the subway have been filled by “place stone fill" with 1 horizontal and 2 vertical slope through all shears from base surface to bottom elevation of approach slob. Base excavation area behind the wall and the part behind place stone fill have been unrolled and constrained simultaneously by broken stone material and road fill material with 1/2 slope through all shear. System of the structure is reinforced concrete portal frame and its length is 1200 m. Diagonal is 90°. Size and cross section of reinforced bridge which has been considered in the study have been showed at Figure 3.4.

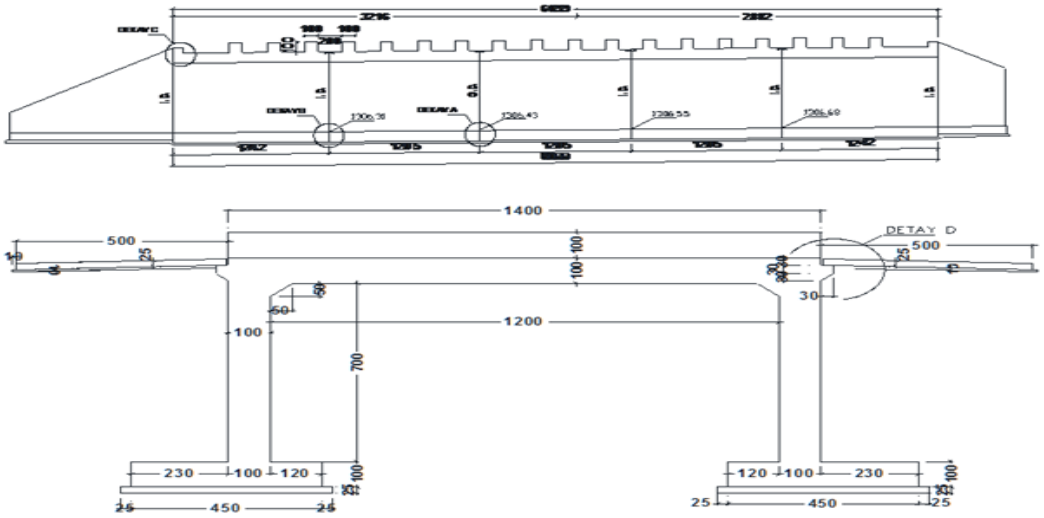

Fig3. 4. The width and length sections of Reinforced Concrete Bridge

Culverts belonging to RC bridge which has been examined in the study and its construction has been completed have been showed at Table 4.

Table4. Quantities belonging to RC bridge which is examined on the study

Beam :1.00x1.00x14.00x18=252.000m³
Body base slab concrete: 60.99x4.50x1.00x2=548.910m³
Approach slab concrete : 0.25x13.25x5.00x4 =66.250m³
Body shear concrete : 2x60.99x1x7.00=853.860m³.
Internal gussets:2x60.99x(05x0.5)/2=15.248m³
Splay concrete: 2x60.99x(0.30+0.60)/2x0.30=16.467m³.
Body bridge floor concrete: 60.99x1.00x14.00=83.860m³.
Entry and exit kerb concrete :2x14.00x0.90x0.50=12.600m³
V1- Raft concrete: 0.75x(12.83x6.2)=59.660m³.
V1- 1 Raft concrete:0.75x(4.96x1.19)/2=2.213m³.
V2 Raft concrete: 0,75x(12.83x6.2)= 59.660m³.
V1-2 Raft concrete:0.75x(4.96x1.19)/2=2.213m³.
Minha (shade area):=2x(0.75x(2.50x0.60)/2)=-1.126m³
V3 Raft concrete:13.50x0.70x (8.50+2.50) / 2= 51.975 m³
V4 Raft concrete:13.50x0.70x (8.50+2.50) / 2= 51.975 m³
V1- Raft concrete:0.75x (4.83x6.20) = 22.460 m³
V2 Raft concrete:0.75x (12.33x6.20) =57.335 m³
V2-1Raft concrete:0.75x (4.96x1.19) / 2=2.213 m³
V2-2 Raft concrete:0.75x (4.96x1.19) / 2= 2.213 m³
Minha (shade area): 2x(0.75x(2.50x0.60)/2)=-1.126m³
V3 Raft concrete:5.50x0.70x (6.00+8.50) / 2= 27.913m³
V4 Raft concrete: 13.00x0.70x (2.60+8.50) / 2= 50.505m³
TOTAL = 2237,278m³

IV. Cost Calculation Belonging To Inspected Works Of Arts

Amount of Concrete used for each work of art which has been examined in the study has been calculated above as depending on culvert and it has been showed at Table 5.

Table5. The amount of concrete used in works of art which is chosen as sample

Type of structure	Concrete amount (m^3)
Box culvert	2.354,148
Retaining wall	156,975
RC Bridge	2.237,278

While cost calculation has been made for each concrete class, unit prices given by The Ministry of Urbanization have been used [10]. These unit prices have been given at Table 6.

Table6. Unit prices belonging to different concrete classes [10]

Concrete class	Item no.	Unit price (TL/m³)
C20	Y.16.050/04	149,88
C25	Y.16.050/05	158,63
C30	Y.16.050/06	172,38
C35	Y.16.050/07	178,63
C40	Y.16.050/08	188,63
C45	Y.16.050/09	196,13

The effect of change in concrete class on each work of art on the cost of chosen work of art has been given at Table 7.

Table7. The cost calculation for different concrete classes for each work of art

Type of structure	Concrete Amount (m³)	C20		C25		C30	
		Unit price (TL/m³)	Total price (TL)	Unit price (TL/m³)	Total price (TL)	Unit price (TL/m³)	Total price (TL)
Box culvert	2.354,148	149,88	352.839,70	158,63	373.438,50	172,38	405.808,03
Retaining wall	156,975	149,88	23.527,41	158,63	24.900,94	172,38	27.059,35
RC bridge	2.237,278	149,88	335.323,23	158,63	354.899,41	172,38	385.661,97

Type of structure	Concrete Amount (m^3)	C35		C40		C45	
		Unit price (TL/m^3)	Total price (TL)	Unit price (TL/m^3)	Total price (TL)	Unit price (TL/m^3)	Total price (TL)
Box culvert	2.354,148	178,63	420.521,46	188,63	444.062,94	196,13	461.719,05
Retaining wall	156,975	178,63	28.576,33	188,63	30.176,08	196,13	31.375,90
RC bridge	2.237,278	178,63	399.644,97	188,63	422.017,75	196,13	438.797,33

V. Comparison Of Workmanship Values For Concrete

By This Research, Man-Hour Values For Concrete Have Been Obtained From The Ministry Of Environment And Urban Planning. Man-Hour Values Obtained From Interviewed Companies Were Organized And Compared. Comparison Results Are Given In Table 9.

Table9. Man-Hour Values According to concrete

Number	Item Number	Work Phases	Measurement Unit	MEUP	Mean	Ratio
1	All of Item number	Produced or Purchased C20/C25 Central-Mixed Concrete and Concrete Pumping	m^3	0.45	0.18	2.50

Description of the columns in Table 9 is given below:

The pose number describes the encoding used description of manufacturing by the Ministry of Environment and Urban Planning. Here, only pose numbers of man-hour values of the present study are taken into account.

Work phases indicate the manufacturing names that the names have been described by the Ministry of Environment and Urban Planning's pose numbers that used in the study.

Measurement unit implies the unit of manufacturing described in the relevant pose.

MEUP describes the man-hour relationship that anticipated for relevant manufacturing unit price found by analyzing the Ministry of Environment and Urban Planning. For instance; manufacturing pose analysis of "concrete" which a pose number of Y.16.050/05 has given in the Table 10.

Table10. Analysis of Y.16.050/05 [6]

Administrative Code	Fair Number	Definition	Unit	Amount
BAY	04.042/05	Concrete mortar for C25/C30	m^3	1.000
BAY	04.031	Water	m^3	0.400
BAY	03.537(Y)	Concrete pump	Hour	0.0100
BAY	01.015	Concrete master	Hour	0.1500
BAY	01.501	Construction Worker	Hour	0.3000
BAY	03.527(Y)	Concrete vibrator	Hour	0.0500

Man-hour values of referred pose number are found in the Table 11 below:

Table 11. Man-hour values of Y.16.050/05 numbered pose

Definition	Unit	Amount
Concrete master	Hour	0.150
Construction worker	Hour	0.300
	Total	0.4500

Mean states that the average of different man-hour values which obtained from survey performed for work phase of construction companies.

The comparison of workmanship values for MEUP and mean was given in Table 12.

Table12. Comparison od workmanship values

Type of structure	Concrete amount (m^3)	Total workmanship MEUP (hour)	Total workmanship for Mean value (hour)
Box culvert	2.354,15	1.059,367	423,747
Retaining wall	156,975	70,639	28,256
RC Bridge	2.237,28	1.006,775	402,710

VI. Conclusions

The effect of concrete strength on the cost for works of art has been revealed by this study. In this sense, three different works of art as box culvert, bridge and sustaining wall have been chosen. The amount of concrete which will be used on each work of art has been calculated as depending on quantities and the cost calculation has been made for different concrete classes. Constructions of all works of art which have been chosen on the study have been completed and they have been opened to be used. This selection has provided that the results are to be more realists.

The increase of concrete strength increases the strength under horizontal and vertical loads of reinforced concrete structures. Even if the use of concretes which have got high concrete strength increases the cost, it will decrease the size of concrete which will be used. Being economical of reinforced concrete structures is based on many parameters. The increase of concrete strength does not only mean being economical.

When there are damage on reinforced concrete type structures, the first thing coming into mind is that concrete strength is low. So the vulnerability of structures which are obtained by these concretes will affect positively by the selection of high-strength concretes. The increase rates of concrete classes which have been examined on the study by C20 which is the smallest concrete class were given in Table 8.

Table 8: Increase rates of concrete class change in the cost of structure

Concrete Class	C25	C30	C35	C40	C45
Increase rate (%)	5,8	15	19	26	30

The selection of concrete class as an upper-level concrete class increases the cost as average 7 % rate. Even if the value increases the cost, when damages that occur on the structures are considered, it is not a rate to require concern for the cost.

The manpower and time concepts constitute the most important part of planning the construction works. A unity that will be created with these two concepts will make work progress and time management much easier. In the construction sector, in order to reach a better future targets this unity is needed.

The development of technology is closely followed and widely used by the construction sector. Man-hour relationship will be a variable parameter with the use of technology. Therefore, it is important to update these values.

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