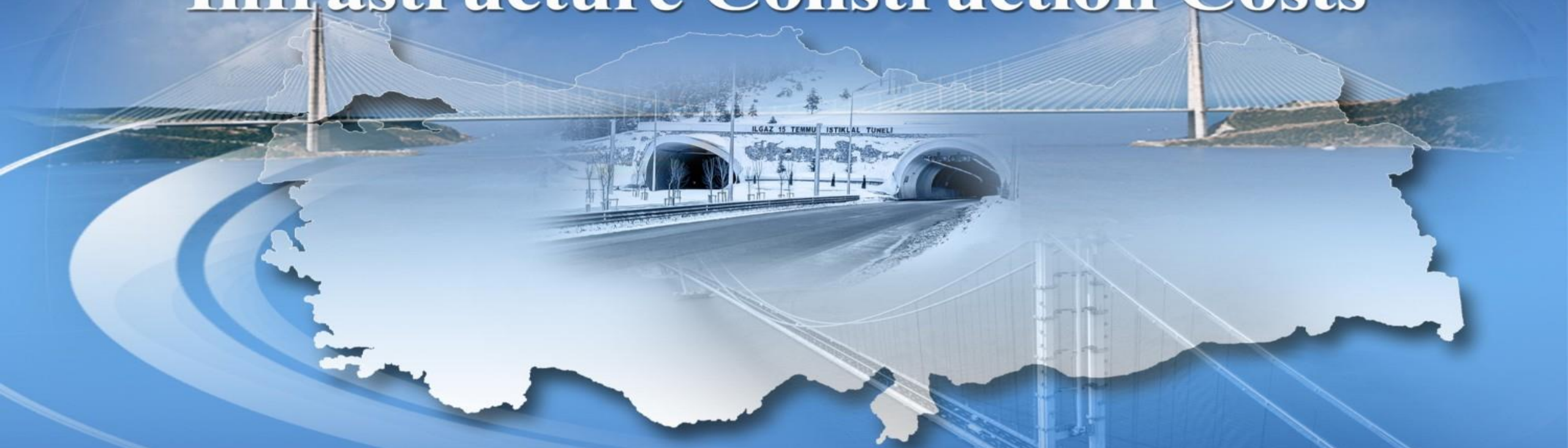
Republic of Turkey
Ministry of Transport Maritime Affairs
and Communications

KGM
GENERAL DIRECTORATE
of HIGHWAYS

# Benchmarking Transport Infrastructure Construction Costs




## GENEVA

10 - 11 APRIL 2017

UNECE

# OUTLINE

I. PROPOSED TERMINOLOGY
II. OVERVIEW OF MAIN CONCERNS AND CONSIDERATIONS
    1. PROPOSED COST PARAMETERS
    2. PROPOSED BENCHMARKING PARAMETERS
III. METHODOLOGY
IV. SAMPLE STUDY AND SAMPLE TABLES

# I. PROPOSED TERMINOLOGY

STATE OF ART

(According to literature review and existing knowledge and experience)

# WHAT IS COST

Cost is a basic “yard stick” by which activities and assets are measured and compared. The word cost is so commonly used and generally related to monetary value. (AACE International) “Skills and Knowledge of Cost Engineering ”

# WHAT IS ROAD INFRASTRUCTURE

Road facilities and equipment, including the network, parking spaces, stopping places, draining system, bridges and footpaths. (WHO)

Suggestion by KGM is adding Tunnels to the definition

## The Road Costs are divided into

1. Cost of Capital
   (=Road Infrastructure Assets) Comprises net investments (Construction of new roads, enlargement, replacement, reconstruction etc.)
2. Running costs
   1. Road Maintenance
   2. Road Operation
   3. Administration/Police

## Road Infrastructure Costs are divided into

- Land Acquisition
- Design
- Environmental Mitigation
- Construction
  - Earthworks
  - Superstructures
  - Pavement
  - Bridges, Tunnels
  - Miscellaneous (Traffic signs, service areas etc.)
- Project Management

# ROAD CLASSIFICATION

**CLASSIFICATION 1**

- INTERURBAN ROADS
- URBAN ROADS

**CLASSIFICATION 2**

- HIGH CLASSIFIED ROADS
  - MOTORWAYS
  - EXPRESSWAYS
- MEDIUM CLASSIFIED ROADS
  - STATE ROADS
  - PROVINCIAL ROADS
- LOW CLASSIFIED ROADS
  (Low Volume Rural Roads)

Suggestion by KGM about classification to be used is the second one

# TERMINOLOGY ON INVESTMENT AND MAINTENANCE

**INVESTMENT**

- Resurfacing
- Resurfacing by Strengthening
- Pavement Replacement
- Reconditioning
- Reconstruction
- Expansion (Capacity Improvement)
- New Construction

**MAINTENANCE**

- Routine Maintenance
- Reactive Maintenance
- Preventive Maintenance
- Deferred Maintenance
- Rehabilitation

In the following table distinction between investment (construction) and maintenance highway activities are given. Regarding this table surface replacement is light rehabilitation on the other hand pavement replacement and reconditioning is heavy rehabilitation. This table also brings to mind whether light rehabilitation is investment or maintenance.

From this point it is necessary to define routine and periodic maintenance.

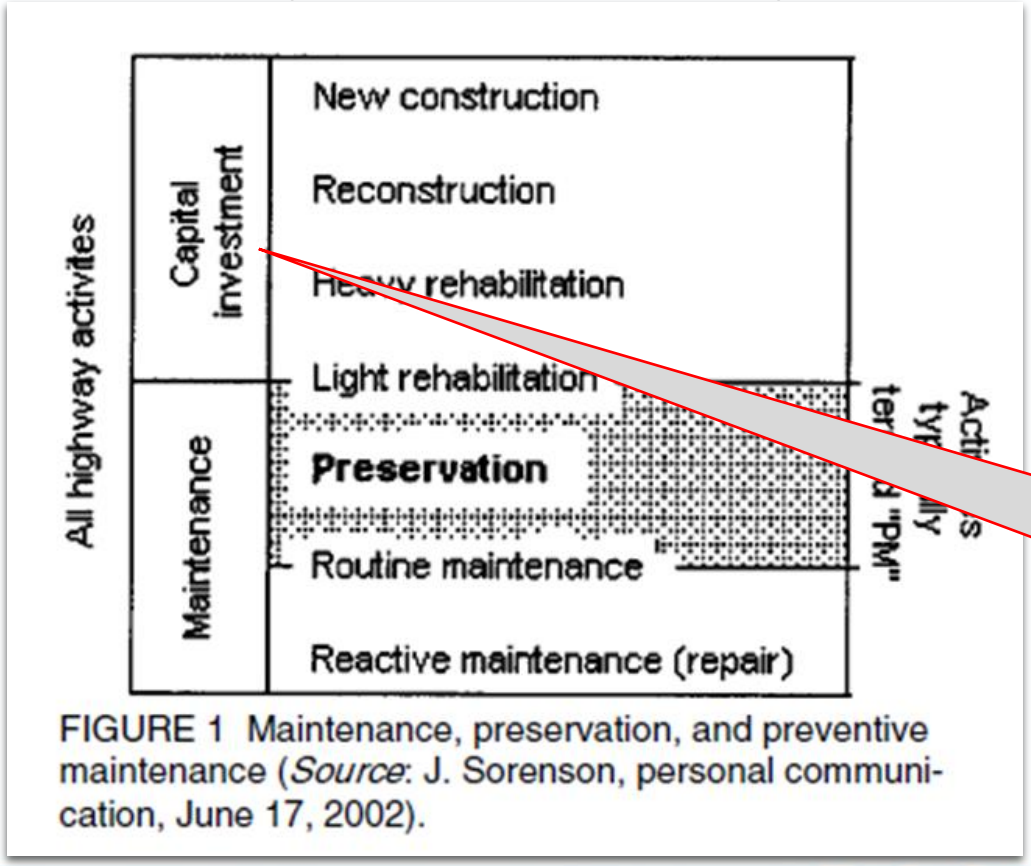



FIGURE 1 Maintenance, preservation, and preventive maintenance (*Source*: J. Sorenson, personal communication, June 17, 2002).

1. Routine Maintenance
2. Preventive Maintenance
3. Deferred Maintenance
4. Rehabilitation
5. Reconstruction

KGM delegation proposal is focusing on investment projects

# TERMINOLOGY ON MAINTENANCE

Any facility and/or structure wear off due to aging and environmental affects (weather condition, natural events, etc.). If this structure of facility is road or bridge, then the load of traffic accelerates this aging and/or deteoriation as a result service level of the structure gets lower. In order to increase service level of any structure or facility the following works supposed to be done.

1- Routine Maintenance
2- Preventive Maintenance
3- Deferred Maintenance
4- Rehabilitation (Reconditioning)
5- Reconstruction

***Some of the works given on left side are maintenance and some of them are investment (construction). Routine maintenance, periodic maintenance and urgent maintenance are the concepts about maintenance and definitions are given in the following slides. On the other hand some of the rehabilitation works are regarded as maintenance.***

# TERMINOLOGY ON INVESTMENT

## Resurfacing:

Placing a new surface of an existing road in order to service in good condition, to increase skid resistance, to seal by aiming to preserve road from negative atmospheric conditions, to increase driver comfort, to extend pavement life, etc. The aim is not to increase the bearing capacity of pavement however to extend lifetime by preserving the road from bad weather conditions. The lifetime of road resurfacing is nearly 5 years or less.



# TERMINOLOGY ON INVESTMENT

## Resurfacing by Strengthening:

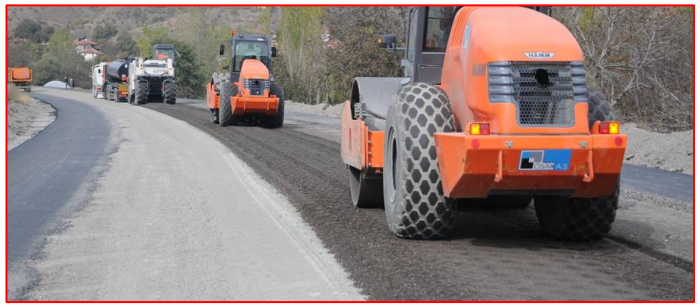
Renewing of road surface with reinstalling bituminous layer either by directly or by removing determined depth of pavement by milling in order to increase bearing capacity of road and to eliminate road defects. The lifetime is nearly 5 to 15 years.

# TERMINOLOGY ON INVESTMENT

## Pavement Replacement:

Renewing of the pavement either by removing the total thickness of all paving layers, existing asphalt layers from an existing roadway or not, and providing a new paved surface without changing capacity or geometry of the road, i.e. without changing subgrade. The lifetime of this kind of projects are 15-20 years.



# TERMINOLOGY ON INVESTMENT

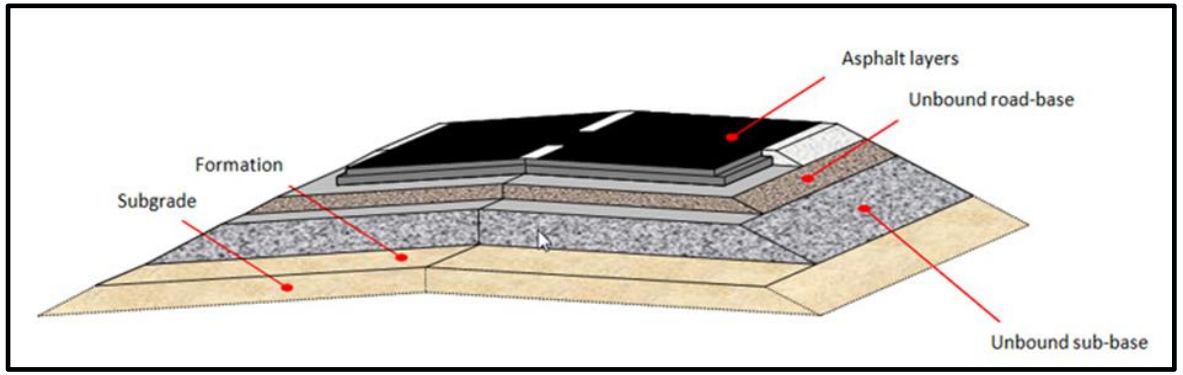
**Reconditioning:**

Reconditioning includes improvement of grades, curves, intersections or sight distances in order to improve traffic safety or changing the subgrade to widen shoulders or to correct structural problems in addition to resurfacing or pavement replacement. The lifetime of these projects are more than 20 years.

# TERMINOLOGY ON INVESTMENT

## Reconstruction:

Total rebuilding of both pavement and subgrade of an existing highway. Work which either changes the location of the existing subgrade shoulder points or removes all of the existing pavement and base course for at least 50% of the length of the project. In other words it is the rebuilding of an existing roads' pavement and subgrade to correct road geometry, to increase road safety, to ease maintenance works and to increase preservation. Reconstruction projects lifetime is generally 20-25 years.



# TERMINOLOGY ON INVESTMENT

**Expansion (Capacity Improvement):**

Same as reconstruction and also involves the construction of additional through travel lanes beyond the work associated with reconstruction.

# II. OVERVIEW OF MAIN CONCERNS AND CONSIDERATIONS

## 1. PROPOSED COST PARAMETERS

WHILE CALCULATING ROAD CONSTRUCTION COSTS AND DOING ANALYSIS WHICH PARAMETERS SOULD BE USED

# CONSTRUCTION COST SHOULD BE CALCULATED EITHER FROM REALIZED PROJECTS AND REALIZED COSTS OR SHOULD BE FORECASTED BY PRACTICING UNIT COSTS ON VIRTUAL PROJECTS ??????????????????

- FROM REALIZED PROJECTS
- FROM VIRTUAL PROJECTS REGARDING UNIT COSTS

# CONSTRUCTION COST SHOULD BE CALCULATED ACCORDING TO TERRAIN TYPE ????????

- FLAT
- ROLLING
- MOUNTANEOUS

# CONSTRUCTION COST SHOULD BE CALCULATED ACCORDING TO ROAD DEFINITIONS ???????

- MOTORWAYS (LIMITED ACCESS HI GHWAYS)
- PRIMARY ROADS
- SECONDARY AND OTHER ROADS

- RURAL
- URBAN

Suggestion by KGM is regarding this classification since there are not enough sample to do analysis for realized projects according to second classification

# CONSTRUCTION COST SHOULD BE CALCULATED ACCORDING TO PROJECT SIZE ???????

- Small Size Projects
- Medium Size Projects
- Large Size Projects
- Mega Projects

## SCALING FOR TURKISH REPUBLIC ROAD INFRASTRUCTURE PROJECTS

**TOTAL COST OF THE PROJECTS**

- **Small Size Projects** <100 Million TL
- 100 Million TL<= **Medium Size Projects** <500 Million TL
- 500 <= **Large Size Projects** <1.000 Million TL
- **Mega Projects** >=1.000 Million TL (Projects have 6C Properties (Colossal, Costly, Captivating, Controversial, Complex, Control Issue) are defined as mega projects.

# CONSTRUCTION COST SHOULD BE CALCULATED IN TERMS OF WHICH UNITS ??????????

- US $  LANE/KM
- US $ /KM
- BOTH

# COST SHOULD INCLUDE OR EXCLUDE THE FOLLOWING WORKS ITEMS ??????????

- TUNNELS
- VIADUCTS
- BRIDGES
- DESIGN COST
- EXPROPRIATION

# COST SHOULD BE GIVEN SEPERATELY FOR THE FOLLOWING STRUCTURES OR NOT ?????

**In terms of unit and/or ratio**

- EXPROPRIATION
- DESIGN
- CONSTRUCTION
  - EARTHWORKS
  - SUPERSTRUCTURES
  - PAVEMENT
  - TUNNELS
  - BRIDGES
  - VIADUCTS
  - MISCELLANEOUS

Suggestion by KGM
is giving in terms of ratio

# II. OVERVIEW OF MAIN CONCERNS AND CONSIDERATIONS

## 2. PROPOSED BENCHMARKING PARAMETERS

SUGGESTIONS ON BENCMARKING PARAMETERS

# OTHER BENCHMARKS ??????????

- GNP
- POPULATION
- LAND SQUARE
- DENSITY
- LENGTH OF ROADS (Motorways, Primary Roads, Secondary Roads, Other Roads)
- ANNUAL BUDGET
- RATIO OF ANNUAL INVESTMENT AND MAINTENANCE BUDGET
- ROAD INFRASTRUCTURE COSTRUCTION COSTS (Euro/Km, Euro/LanexKm)
- ANNUAL CONSTRUCTED ROADS IN LENGTH
- ANNUAL CONSTRUCTED BRIDGES IN LENGTH
- ANNUAL COSTRUCTED TUNNELS IN LENGTH
-
-
-

| | COUNTRIES | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | |
| **GNP** | | | | | | | | |
| **POPULATION** | | | | | | | | |
| **LENGTH OF ROADS** | | | | | | | | |
| MOTORWAYS | | | | | | | | |
| STATE ROADS (PRIMARY ROADS) | | | | | | | | |
| SECONDARY ROADS | | | | | | | | |
| OTHER ROADS | | | | | | | | |
| **ANNUAL BUDGET** | | | | | | | | |
| INVESTMENT BUDGET | | | | | | | | |
| RATIO | | | | | | | | |
| CURRENT BUDGET | | | | | | | | |
| RATIO | | | | | | | | |
| **ANNUAL CONSTRUCTED ROADS IN LENGTH (KM)** | | | | | | | | |
| **ANNUAL CONSTRUCTED TUNNELS IN LENGTH (M)** | | | | | | | | |
| **ANNUAL CONSTRUCTED BRIDGES IN LENGTH (M)** | | | | | | | | |
| **ROAD INFRASTRUCTURE CONSTRUCTION COST** | | | | | | | | |
| SMALL SCALED ROADS (EURO/KM) | | | | | | | | |
| SMALL SCALED ROADS (EURO/LANEXKM) | | | | | | | | |
| MEDIUM SCALED ROADS (EURO/KM) | | | | | | | | |
| MEDIUM SCALED ROADS (EURO/LANEXKM) | | | | | | | | |
| LARGE SCALED ROADS (EURO/KM) | | | | | | | | |
| LARGE SCALED ROADS (EURO/LANEXKM) | | | | | | | | |
| MEGA SCALED ROADS (EURO/KM) | | | | | | | | |
| MEGA SCALED ROADS (EURO/LANEXKM) | | | | | | | | |
| **UNIT CONSTRUCTION COST OF TUNNELS** | | | | | | | | |
| SINGLE TUBE TUNNEL (EURO/M) | | | | | | | | |
| TWIN TUBE TUNNEL (EURO/M) | | | | | | | | |
| **UNIT CONSTRUCTION COST OF BRIDGES** | | | | | | | | |
| PRESTRESSED SIMPLE BEAM (EURO/$M^2$) | | | | | | | | |
| BALANCED CANTILIVER BRIDGE (EURO/$M^2$) | | | | | | | | |
| CABLE STAYED BRIDGE (EURO/$M^2$) | | | | | | | | |

# III. METHODOLOGY

## PROPOSALS ON METHODOLOGY

i. DESCRIPTIVE ANALYSIS

ii. REGRESSION ANALYSIS

BOTH DONE FOR KGM STUDY SINCE DATA DO NOT FIT NORMAL DISTRIBUTION WE PREFER DESCRIPTIVE ANALYSIS AND DRAWING BOX PLOT DIAGRAMS. IN ADDITION TUNNEL EXISTENCE IS OBTAINED AS THE MOST IMPORTANT PARAMETERS FOR REGRESSION ANALYSIS.

# IV. SAMPLE STUDY AND SAMPLE TABLES

(II PHASE OF KGM STUDY)

# THE FOLLOWING SLIDES COVERS COST CALCULATION OF THE ROAD CONSTRUCTION PROJECTS COMPLETED WITHIN LAST 15 YEARS

- Number of analyzed road projects are ~100
- Number of analyzed bridge projects are ~150

# SUPERSTRUCTURES UNIT COSTS (Euro/m2) FROM REALIZED PROJECTS

**2017 PRICES**

| CENTER LEG TYPE | Number of Analyzed Bridges | Minimum (€/m2) | Maximum (€/m2) | Average (€/m2) | Median (€/m2) |
|---|---|---|---|---|---|
| SINGLE COLUMN | | | | | |
| MULTI COLUMN | | | | | |
| SHEAR WALK | | | | | |
| WITHOUT COLUMN (Single Clearance) | | | | | |
| TOTAL | | | | | |

| FOUNDATION TYPE | Number of Analyzed Bridges | Minimum (€/m2) | Maximum (€/m2) | Average (€/m2) | Median (€/m2) |
|---|---|---|---|---|---|
| SHALLOW FOUNDATION | | | | | |
| DEEP PILED FOUNDATION | | | | | |
| TOTAL | | | | | |

| BRIDGE TYPE (Static System) | Number of Analyzed Bridges | Minimum (€/m2) | Maximum (€/m2) | Average (€/m2) | Median (€/m2) |
|---|---|---|---|---|---|
| Reinforced Concrete Single Beam Bridge | | | | | |
| Reinforced Concrete Single Slab Bridge | | | | | |
| Reinforced Concrete Continuous Beam Bridge | | | | | |
| Reinforced Concrete Prestressed Single Beam Bridge | | | | | |
| TOTAL | | | | | |

## ROAD UNIT COSTS (Euro/Km)
## (Including tunnels, bridges and viaducts) FROM REALIZED PROJECTS

**2017 PRICES**

| ROAD PROJECT SIZE | Number of Analyzed Roads | Minimum (€/Km) | AVERAGE (€/ Km) | Maximum (€/Km) | Median (€/Km) |
|---|---|---|---|---|---|
| SMALL SIZE PROJECTS | | | | | |
| MEDIUM SIZE PROJECST | | | | | |
| LARGE SIZE PRIOJECTS | | | | | |
| MEGA PROJECTS | | | | | |
| TOTAL | | | | | |

## ROAD UNIT COSTS (Euro/LanexKm)
## (Including tunnels, bridges and viaducts) FROM REALIZED PROJECTS

2017 PRICES

| ROAD PROJECT SIZE | Number of Analyzed Roads | Minimum (€/Lane x Km) | AVERAGE (€/Lane x Km) | Maximum (€/Lane x Km) | Median (€/Lane x Km) |
|---|---|---|---|---|---|
| SMALL SIZE PROJECTS | | | | | |
| MEDIUM SIZE PROJECST | | | | | |
| LARGE SIZE PRIOJECTS | | | | | |
| MEGA PROJECTS | | | | | |
| TOTAL | | | | | |

# SAMPLE TABLE FOR MOTORWAYS

| ROAD CLASSIFICATION | TERRAIN TYPE | GEOMETRIC STANDARD | UNIT COSTS | |
|---|---|---|---|---|
| | | | €/km | €/laneXkm |
| HIGH CLASSIFIED ROADS (MOTORWAYS) | FLAT | 2X1 | | |
| | | 2X2 | | |
| | | 2X3 | | |
| | | MORE LANES | | |
| | ROLLING | 2X1 | | |
| | | 2X2 | | |
| | | 2X3 | | |
| | | MORE LANES | | |
| | MOUNTANEOUS | 2X1 | | |
| | | 2X2 | | |
| | | 2X3 | | |
| | | MORE LANES | | |

# SAMPLE TABLE FOR PRIMARY ROADS

| ROAD CLASSIFICATION | TERRAIN TYPE | GEOMETRIC STANDARD | UNIT COSTS | |
|---|---|---|---|---|
| | | | €/km | €/laneXkm |
| MEDIUM CLASSIFIED ROADS (STATE ROADS) (PRIMARY ROADS) | FLAT | 2X1 | | |
| | | 2X2 | | |
| | | 2X3 | | |
| | | MORE LANES | | |
| | ROLLING | 2X1 | | |
| | | 2X2 | | |
| | | 2X3 | | |
| | | MORE LANES | | |
| | MOUNTANEOUS | 2X1 | | |
| | | 2X2 | | |
| | | 2X3 | | |
| | | MORE LANES | | |

# SAMPLE TABLE FOR SECONDARY ROADS

| ROAD CLASSIFICATION | SCALE OF THE PROJECT | TERRAIN TYPE | GEOMETRIC STANDARD | UNIT COSTS | |
|---|---|---|---|---|---|
| | | | | €/km | €/laneXkm |
| MEDIUM CLASSIFIED ROADS (SECONDARY ROADS) | SMALL | FLAT | 2X1 | | |
| | | | 2X2 | | |
| | | | 2X3 | | |
| | | | MORE LANES | | |
| | | ROLLING | 2X1 | | |
| | | | 2X2 | | |
| | | | 2X3 | | |
| | | | MORE LANES | | |
| | | MOUNTANEOUS | 2X1 | | |
| | | | 2X2 | | |
| | | | 2X3 | | |
| | | | MORE LANES | | |

## COSTS (€/Lanexkm) FROM REALIZED PROJECTS

| ADMINISTRATIVE CLASSIFICATION | PAVEMENT TYPE | COST INCLUDES OR EXCLUDES TUNNESL, BRIDGES AND VIADUCTS | NUMBER OF LANES | SAMPLE SIZE | MINIMUM | AVERAGE | MAXIMUM | MEDIAN | STANDART DEVIATION |
|---|---|---|---|---|---|---|---|---|---|
| SECONDARY ROADS | SURFACE TREATMENT | INCLUDE | 2x1 | | | | | | |
| | | | 2x2 | | | | | | |
| | | EXCLUDE | 2x1 | | | | | | |
| | | | 2x2 | | | | | | |
| | ASPHALT CONCRETE | INCLUDE | 2x1 | | | | | | |
| | | | 2x2 | | | | | | |
| | | EXCLUDE | 2x1 | | | | | | |
| | | | 2x2 | | | | | | |
| STATE ROADS | SURFACE TREATMENT | INCLUDE | 2x1 | | | | | | |
| | | | 2x2 | | | | | | |
| | | EXCLUDE | 2x1 | | | | | | |
| | | | 2x2 | | | | | | |
| | ASPHALT CONCRETE | INCLUDE | 2x1 | | | | | | |
| | | | 2x2 | | | | | | |
| | | EXCLUDE | 2x1 | | | | | | |
| | | | 2x2 | | | | | | |

## COST (€/Km) FROM REALIZED PROJECTS

| ADMINISTRATIVE CLASSIFICATION | PAVEMENT TYPE | COST INCLUDES OR EXCLUDES TUNNESL, BRIDGES AND VIADUCTS | NUMBER OF LANES | SAMPLE SIZE | MINIMUM | AVERAGE | MAXIMUM | MEDIAN | STANDART DEVIATION |
|---|---|---|---|---|---|---|---|---|---|
| SECONDARY ROADS | SURFACE TREATMENT | INCLUDE | 2x1 | | | | | | |
| | | | 2x2 | | | | | | |
| | | EXCLUDE | 2x1 | | | | | | |
| | | | 2x2 | | | | | | |
| | ASPHALT CONCRETE | INCLUDE | 2x1 | | | | | | |
| | | | 2x2 | | | | | | |
| | | EXCLUDE | 2x1 | | | | | | |
| | | | 2x2 | | | | | | |
| STATE ROADS | SURFACE TREATMENT | INCLUDE | 2x1 | | | | | | |
| | | | 2x2 | | | | | | |
| | | EXCLUDE | 2x1 | | | | | | |
| | | | 2x2 | | | | | | |
| | ASPHALT CONCRETE | INCLUDE | 2x1 | | | | | | |
| | | | 2x2 | | | | | | |
| | | EXCLUDE | 2x1 | | | | | | |
| | | | 2x2 | | | | | | |

# Unit Costs (€/Km) FROM REALIZED PROJECTS

| ADMINISTRATIVE CLASSIFICATION | PAVEMENT TYPE | Cost of Projects Including Viaducts, Bridges and Tunnels | SCALE OF THE PROJECT | SAMPLE SIZE | Minimum | Mean | Maximum | Median | Standard Deviation |
|---|---|---|---|---|---|---|---|---|---|
| SECONDARY ROADS | SURFACE TREATMENT | INCLUDE | Small | | | | | | |
| | | | Medium | | | | | | |
| | | | Large | | | | | | |
| | | | Mega | | | | | | |
| | | EXCLUDE | Small | | | | | | |
| | | | Medium | | | | | | |
| | | | Large | | | | | | |
| | | | Mega | | | | | | |
| | | Percentage Increase | Small | | | | | | |
| | ASPHALTH CONCRETE | INCLUDE | Small | | | | | | |
| | | | Medium | | | | | | |
| | | | Large | | | | | | |
| | | | Mega | | | | | | |
| | | EXCLUDE | Small | | | | | | |
| | | | Medium | | | | | | |
| | | | Large | | | | | | |
| | | | Mega | | | | | | |
| | | Percentage Increase | Small | | | | | | |
| | | | Medium | | | | | | |
| STATE ROADS | SURFACE TREATMENT | INCLUDE | Small | | | | | | |
| | | | Medium | | | | | | |
| | | | Large | | | | | | |
| | | | Mega | | | | | | |
| | | EXCLUDE | Small | | | | | | |
| | | | Medium | | | | | | |
| | | | Large | | | | | | |
| | | | Mega | | | | | | |
| | | Percentage Increase | Small | | | | | | |
| | | | Medium | | | | | | |
| | ASPHALTH CONCRETE | INCLUDE | Small | | | | | | |
| | | | *Medium* | | | | | | |
| | | | Large | | | | | | |
| | | | Mega | | | | | | |
| | | EXCLUDE | Small | | | | | | |
| | | | *Medium* | | | | | | |
| | | | Large | | | | | | |
| | | | Mega | | | | | | |
| | | Percentage Increase | Small | | | | | | |
| | | | Medium | | | | | | |
| | | | Large | | | | | | |
| | | | Mega | | | | | | |

# ROAD CONSTRUCTION COSTS (TAX EXCLUDED)
# (ACCORDING TO TERRAIN TYPE, HEAVY VEHICLE TRAFFIC AND PLATFORM WIDTH)

**Unit Costs (€/Km) FROM VIRTUAL PROJECTS**

(Euro/KM)

| TERRAIN TYPE | HEAVY VEHICLE TRAFFIC | PAVEMENT TYPE | | PLATFORM WIDTH(m) | | | |
|---|---|---|---|---|---|---|---|
| | | | | 8.00 | 10.00 | 12.00 | Dual Carriageway |
| FLAT | 0-50 | Single Layer Surface Treatment (Cross Section Type 1) | Earthworks | | | | |
| | | | Structures | | | | |
| | | | Pavement | | | | |
| | | | Total | | | | |
| | 50-250 | Double Layer Surface Treatment (Cross Section Type 2) | Earthworks | | | | |
| | | | Structures | | | | |
| | | | Pavement | | | | |
| | | | Total | | | | |
| | 250-500 | Asphaltic Concrete (Cross Section Type 3-1) | Earthworks | | | | |
| | | | Structures | | | | |
| | | | Pavement | | | | |
| | | | Total | | | | |
| | 250-500 | Asphaltic Concrete (Cross Section Type 3-2) | Earthworks | | | | |
| | | | Structures | | | | |
| | | | Pavement | | | | |
| | | | Total | | | | |
| | 500 - 1500 | Asphaltic Concrete (Cross Section Type 4) | Earthworks | | | | |
| | | | Structures | | | | |
| | | | Pavement | | | | |
| | | | Total | | | | |
| | 1500 - 3000 | Asphaltic Concrete (Cross Section Type 5) | Earthworks | | | | |
| | | | Structures | | | | |
| | | | Pavement | | | | |
| | | | Total | | | | |

THIS TABLE WILL BE FILLED FOR ROLLING AND MAOUNTANEOUS TERRAIN TYPE ALSO

## ASSUMPTIONS FOR ROAD CONSTRUCTION COSTS

- All filling materials made in a flat terrain are fulfilled from borrow pit.
- In rolling and mountainous terrains, 60% of cut excavation material is used for filling, remaining 40% is sent to storage. The remaining filling requirement is fulfilled from borrow pit.
- The distances in terms of transportation are accepted as 750 m for cut excavation, 2.000 m for water transplantation and 5.000 m for borrow pit or storage excavation. Furthermore, haulage amounts less than 150 m are not included to volumes for 1 km road (flat, rolling, mountanious).

- On the other hand, for cost calculation 0.30 m weak soil excavation is assumed for filling base.
- In the calculating process of 1 km road substructure construction cost, it is assumed that structure cost is 30% of the earthwork cost for flat terrain, 50% for rolling terrain and 70% for mountanious terrain. Costs of superstructures like bridges and viaducts are not included.
- Survey-Design and expropriation costs are not included.

# ASSUMPTIONS FOR VIRTUAL PROJECTS COST CALCULATIONS FROM VIRTUAL PROJECTS

**VOLUMES USED IN CALCULATING EARTHWORK COSTS**

| TERRAIN TYPE | PLATFORM WIDTH *(m)* | QUANTITY *($m^3$)* | |
|---|---|---|---|
| | | CUT | BORROW PIT |
| FLAT | 12 | - | 35.400 |
| | 10 | - | 30.800 |
| | 8 | - | 26.200 |
| ROLLING | 12 | 42.000 | 12.725 |
| | 10 | 38.250 | 10.925 |
| | 8 | 34.500 | 9.125 |
| MOUNTAINOUS | 12 | 98.000 | 9.200 |
| | 10 | 88.000 | 5.200 |
| | 8 | 78.000 | 1.200 |

BORROW PIT EXCAVATION CLASSES

| TERRAIN TYPE | FLAT | ROLLING | MOUNTAINOUS |
|---|---|---|---|
| EARTH | 10% | 10% | 10% |
| LOOSE MATERİAL | 80% | 80% | 80% |
| SOFT ROCK | 10% | 10% | 10% |

CUTTING EXCAVATION CLASSES

| TERRAIN TYPE | FLAT | ROLLING | MOUNTAINOUS |
|---|---|---|---|
| EARTH | - | 30% | 30% |
| LOOSE MATERİAL | - | 40% | 40% |
| SOFT ROCK | - | 30% | 30% |

| For Superstructure Construction | |
|---|---|
| Construction Type | Distance (m) |
| *Stone Transfer Between Pit and Crusher* | 500 |
| *Aggregate Transfer Between Crusher and Plant* | 15.000 |
| *Subbase, Base Transfer from Plant to Road* | 20.000 |
| *Subbase from Crusher to Road* | 20.000 |
| *Water Transfer to Plant* | 2.000 |
| *Bitumen Transfer* | 250.000 |
| *Water Transfer to Road* | 5.000 |
| *Gravel Transfer From Plant to Road* | 20.000 |
| *For Earthwork Construction* | |
| *Construction Type* | *Distance* (m) |
| *Material Excavated From Borrow Pit or Sent to Storage* | 5.000 |
| *Water Transfer* | 2.000 |

# THANK YOU FOR YOUR ATTENTION!


Mücahit ARMAN
Kamuran YAZICI
Dr. Leyla ÜNAL
Fatma ORHAN

**GENERAL DIRECTORATE OF TURKISH HIGHWAYS**

**Ministry of Transport, Maritime Affairs and Communications**