# REHABILITATION PLANNING OF OLD ROAD TUNNELS IN TURKEY

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***SUMMARY***

In 2001, a study was carried out to classify old road tunnels for the rehabilitation plan in Turkey. The study is mainly based on investigation of two groups of effect on tunnels as structural aspects and serviceability. In Turkey, mostly, there are no waterproofing in old tunnels constructed conventionally before 1980. Concrete linings in some of the tunnels are not in good conditions and enough quality. There are water inflows which changes from wet spots to flowing along cracks into the tunnel. Pavements are heavily damaged in some of the tunnels. During the site investigations of tunnels, direct and indirect visual establishments were used. Water flows, cracks and deformations on lining were observed by concerning of geological and geotechnical characteristics of surrounded ground. All data related to structural and water conditions of tunnel were recorded along the tunnels axis and cross section. At the end of the study, old tunnels were categorized in five groups by considering failures, which may effect the lining, major role of the encountering ground, immediate necessity of waterproofing, significance of the road where the tunnel was on. Finally a draft proposal plan is assessed and the tunnels which require a particular rehabilitation or minor repairs were defined.

## *1. INTRODUCTION*

63 old tunnels with a length of 11600 m, which belong to KGM road net and were constructed before 1980 without waterproofing, have been studied in details at 2001 to prepare rehabilitation plan. The study gives structural and service capacity of tunnels. As a result of the study, old tunnels are classified according to different criteria; condition of lining, water inflow, problems due to surrounding rock, condition of pavement and other problems related to serviceability. Finally rehabilitation plan is proposed for tunnels, which requires minor and special rehabilitation.

## *2. MAINTENANCE AND REHABILITATION POLICY FOR TUNNELS IN NATIONAL ROADS*

Maintenance and rehabilitation works of tunnels have been carried out by Maintenance Department of General Directorate of Highways (KGM) from its establishment.

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Control of surface and groundwater drainage, treatment of defects in pavement and minor rehabilitation works, related mainly serviceability, have been carried out by maintenance teams. But works related to the problems, which affect tunnel stability (problems due to surrounding rock, water inflow etc.) are treated according to rehabilitation design in cooperation of Technical Research Department. Rehabilitation design is established considering old construction records, geological and geotechnical investigations, serviceability conditions, cost of rehabilitation alternatives. Recently an old road tunnel with a length of 1 km on main artery was rehabilitated according to its design.

Maintenance and rehabilitation works of motorway tunnels are carried out by Maintenance and Operation Districts of Motorway Department.

### *3-PRICIPLES OF STUDY*

In order to collect required data related to present status of structural and service capacity of tunnels, data collection forms and mapping forms were prepared. With these forms three main type of data were collected. First one is identification data; geometry, geotechnical information related to surrounding rock conditions, information related to tunnel lining, service capacity, lighting, ventilation, drainage. Second one is information related to water inflow ; amount, location etc. Third one is information related to present condition of tunnel lining; cracking, segregation etc. Data related to tunnel lining and water inflow were recorded as mappings (Fig 1). The aim of these data collection forms are to establish an indicator for resemble present condition of tunnels and a common comparison mode in classification of tunnels for rehabilitation purposes.

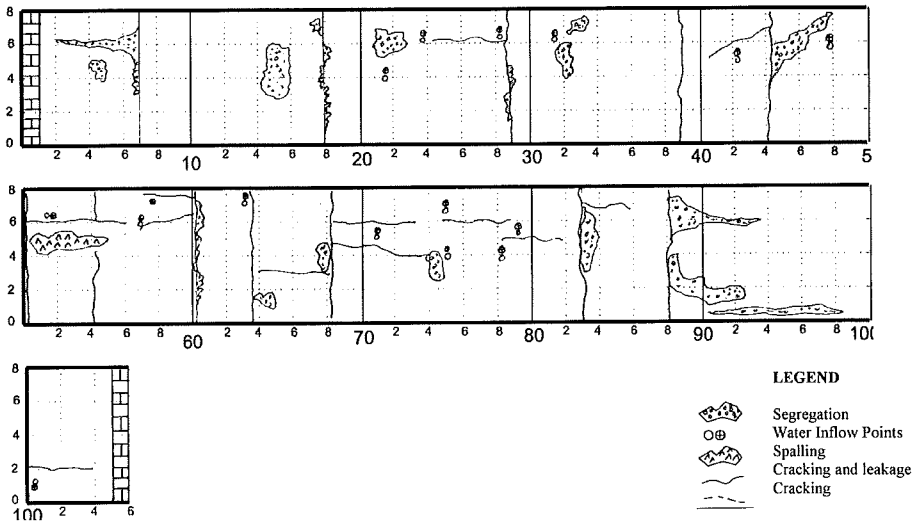


**Figure1 :** Mapping Forms from Yeniköprü Tunnel

Data collection is done according to present geotechnical reports, construction records, routine inspections. Drainage and water insulation at portal area and inside of tunnel were inspected.

### *4-EVALUATION OF TUNNEL DATA*

In this study, 63 old tunnels with a length of 11600 m were evaluated. 25 of 63 tunnels are short tunnels with a individual length of 10-50 m and total length of 1076 m and they are avalanche tunnels. Tunnel data were evaluated in three parts.

### *4.1 WATER EFFECT*

40 of studied tunnels were driven in stable rock conditions, 13 tunnels in weathered rock conditions and 10 tunnels in soil conditions. Effect of water is evaluated as low-medium-high, considering water inflow to tunnel, negative influence of water to tunnel, number of inflow points, defects on concrete lining at water inflow points, reason of water inflow (water is coming from base-surrounding soil/rock or due to unworking of drainage system), freezing- thawing effect etc. All of the tunnels, which were constructed before 1980, lack water proofing, which is essential according to Road Tunnel Construction Specification–1990. 6 tunnels constructed after 1980 without waterproofing are included to the study.

Evaluating water inflow points, wet spots, effect on lining and pavement, considering total length in 45 % of tunnels effect of water inflow is low, in 23% medium, in 32% high (Fig 2).

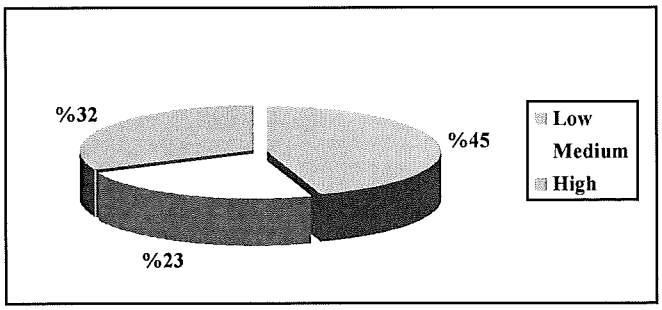


***Figure 2:*** Classification of Tunnels According to Water Effect

Tunnels in which water effect is low are located in relatively low fractured stable rock mass conditions such as crystallized limestone. Water inflow points or wet spots are generally in portal zones or in very friable rock. With decreasing stability of surrounding rock due to water very friable rock turns into weathered rock and effect of water is high. Another interesting point is old construction date (1954-1965) of tunnels in which water effect is high.

### *4.2 CONDITION OF LINING*

**1**-84% of evaluated tunnels has concrete lining, 16 % of them is unlined. In tunnels, 42 % of lined tunnels under high water effect and constructed between 1954-1965, there is high segregation and spalling. Reason for this type of defects is quality of concrete. Concrete class for the concrete lining was BS 16 until 1980 and increased to BS 20 from this date. In addition of low concrete quality, although there is no stability problem, due to concrete technology (casting, wooden formwork, curing conditions, time for removing formwork etc) defects such as segregation and hair cracking turn into wide spreading and serious cracking

**2**-There are 6 tunnels with total length of 1033 m, where increasing weathering of rock behind concrete lining causes additional loading onto lining and high water effect reduces quality of concrete . All those effects bring dangerous conditions for structural stability of tunnel.

For three tunnels located in southeastern part of Turkey, water proofing and rehabilitation of tunnel lining will be enough to increase tunnel stability. Since these three tunnels were excavated in weathered rock conditions such as tuff, serpentine, it should be considered in rehabilitation design, whether a measure should be taken behind the lining or not. In rehabilitation design considering low clearance of tunnel cross section widening requirements should be considered also.

In Arhavi Tunnel, concrete structure at portal zone is broken and there are deformation in the tunnel due to loading from weathered tuff with water effect( Fig 3). Rehabilitation of this tunnel is an urgent work. But because another alignment for state road ( 2x2 lane ) is under design, this tunnel will be temporarily under service and rehabilitation works should be done considering short service time of the tunnel.

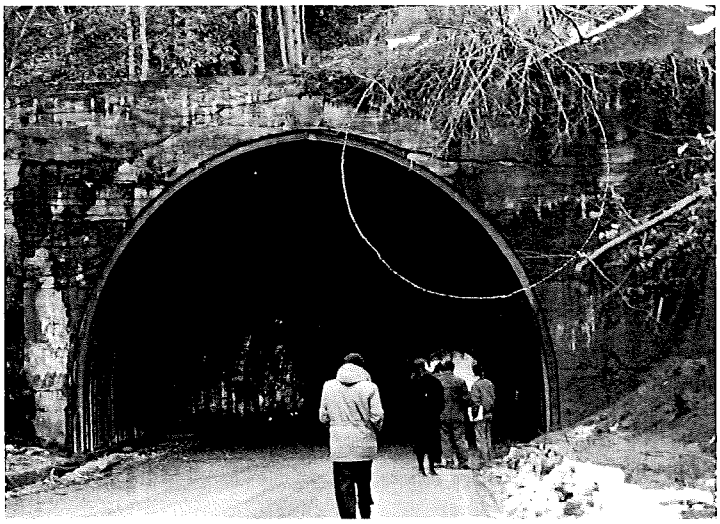

**Figure 3:** Photo from Arhavi Tunnel

Edirnekapı tunnel is a cut and cover tunnel. Due to water effect, segregation of concrete lining, corrosion of steel, there is a decrease in structural capacity of tunnel (Fig 4 ) . This tunnel should be rehabilitated according to special design urgently.

**Figure 4:** Photo from Edirnekapı Tunnel

In 10 avalanche tunnels with 508 m length, there are longitudinal cracks in plain concrete lining due to asymmetrical loading conditions, weak sections due to windows at valley side for lighting. Considering that these avalanche tunnels have very low traffic clearance and new data related to avalanche zones, rehabilitation or reconstruction of these tunnels should be considered.

### *4.3 SERVICEABILITY DATA OF TUNNEL (DRAINAGE, PAVEMENT, LIGHTING, VENTILATION)*

42 % of evaluated tunnels have asphalt concrete pavement, 41 % surface dressing, 17 % concrete pavement. The highest amount of defects in pavement is in concrete pavement with a percentage of 47. There are deformations in 46 % of asphalt pavement and 5 % of surface dressing pavement. Deformations in pavement is due to insufficient drainage system, freezing-thawing effect in concrete pavement in avalanche tunnels and water leakage from tunnel lining. 58 % of tunnels require routine maintenance of drainage systems. There is no ventilation system in studied tunnels. There is lighting in 26 % of tunnels with a length higher than 500 m.

## *5- CLASIFICATION OF THE TUNNELS*

Old tunnels were categorized in five groups by considering failures, which may effect the lining, major role of the encountering ground, immediate necessity of waterproofing, significance of the road where the tunnel was on (Fig 5). Finally a draft proposal plan is assessed and the tunnels which require a particular rehabilitation or minor repairs were defined.

### *1.Class-Routine Maintenance*

Considering lining, pavement tunnel is in good conditions. Tunnel is dry or there is small amount of water. Routine periodic maintenance is required.

20 % of studied tunnels belong to this group.

### *2. Class -Special Maintenance-Local Rehabilitation*

Effect of water inflow is low-medium. There is local segregation in lining, oxidation, hair cracks ( < 5 mm) concrete quality is low. In such tunnels special maintenance measures and measures against water should be taken and local rehabilitation of the pavement can be done.

46 % of studied tunnels belong to this group. In this groups main type of deformation is segregation, local cracking, defects in pavement

### *3. Class- Systematic Rehabilitation*

Effect of water inflow is medium-high. Segregation and spalling in lining are along whole tunnel. There is no stability problem in concrete lining due to surrounding rock/soil conditions. Thickness of cracks in lining is < 1 cm. But if measures are not taken defects can be improved and effect stability of the tunnel. Rehabilitation for water proofing, pavement and other works related to service capacity of the tunnel.

19 % of studied tunnels belong to this group.

### *4. Class- Structural Rehabilitation*

Concrete lining is highly damaged. Effect of water inflow is high. There are radial and longitudinal cracks, convergence in lining and stability problem in lining due to surrounding rock/soil. Rehabilitation design of the tunnel should be done with detailed site investigations (corings from lining, geophysical methods etc) considering old construction data of the tunnel

15 % of studied tunnels belong to this group.

### *5. Class- Urgent Rehabilitation*

Traffic and people safety is in danger due to stability problems in tunnel. Tunnel should be closed to traffic and urgent rehabilitation is required.

There is not such a tunnel from studied tunnels. But tunnels belonging 4. Class can be transfer to this group unless measures will be taken .

If improvement in traffic clearance of tunnel is required, for tunnels in 3. Class rehabilitation design should be done as that in 4. Class

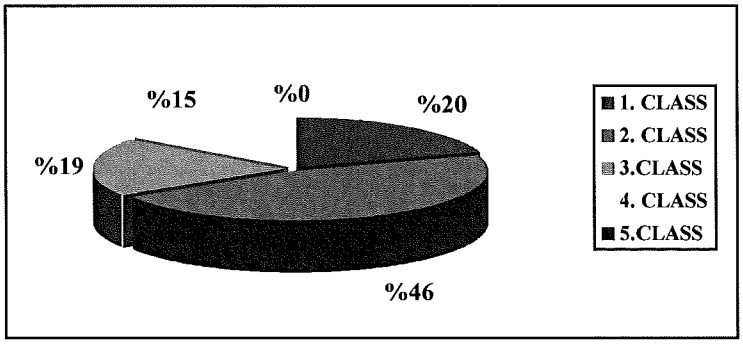


***Figure 5:*** Classification of Tunnels

## *6- CONCLUSION*

Road tunnels which were constructed before 1980 without waterproofing with low concrete quality (BS16) were studied in the scope of the study to evaluate present condition considering performance and structural capacity of lining, water effect, drainage, pavement, lighting, ventilation. These tunnels were classified according to rehabilitation requirements. As a result of this classification there is not tunnel require urgent treatment. But there are tunnels ( 7 tunnels with total length of 1113 m - Class 4) with high segregation and serious cracking under loading of surrounding rock/soil contributed with water inflow and they require site investigations and design works. Priority should be given to tunnels with high traffic volume in rehabilitation plan. There are 21 tunnels with total length of 2162 m (Class 3), which require water proofing along whole tunnel and rehabilitation for minor cracking A draft plan is proposed.

One of the outcome of the study is that classification of the tunnels are directed by amount of water inflow, level of weathering in surrounding rock/soil conditions old concrete technology, decrease in service capacity with water. In tunnels which require routine maintenance amount of inflow water is low, surrounding rock is stable. In tunnels with old construction time (1954-1965) effect of water inflow is high and in portal zones cracking in lining , water inflow points are more, pavement deforms under effect of water. For tunnels in Class 4 rehabilitation design should be done with site investigations and economical comparison of rehabilitation alternatives. Tunnels in Class 1-2-3 should be observed periodically to prevent the unexpected events.

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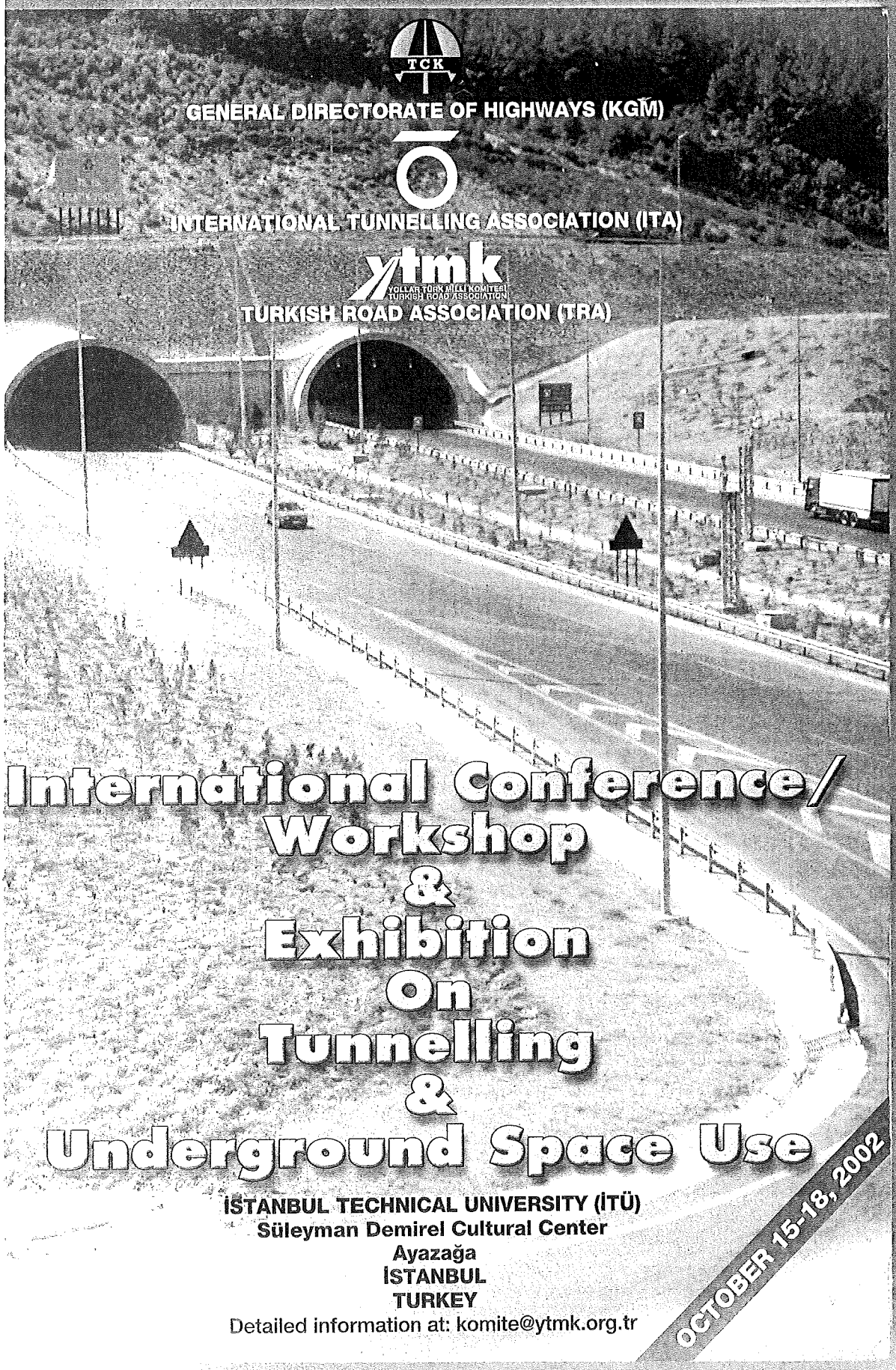

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