



## **Motorway tunnel construction: Is cost variance under control? A study of ten underground structures**

### **Key facts**

---

Various international studies in transport infrastructure have shown that costs are underestimated in nine out of ten projects. On average, actual costs are 30% higher than estimated at the time of project approval. This systematic tendency to underestimate costs applies to all project types. Within infrastructure, the construction of underground structures is particularly costly and complex, especially with respect to managing risk and uncertainty. For this specific type of structure, risk of cost overrun is an even higher 35%.

The Swiss Federal Audit Office (SFAO) has analysed the situation in Switzerland, looking at motorway tunnel projects. The objective of the study was to assess cost variance on the basis of finished projects and to examine, in concrete terms, the accuracy of predicted costs and estimates. It is also about identifying the reasons for a certain cost variance, an aspect closely related to project management and risk control. The SFAO thus selected ten motorway tunnel and underground construction sites for its study. Besides, it looked into an additional project for which the Federal Roads Office (FEDRO) now acts as project owner.

### **Difficult information access and lack of standardisation in the data available**

It became clear to the SFAO from the outset that FEDRO could not provide precise data and information on final project costs or even on how costs evolved in the intermediate phases. Furthermore, no clear distinction was made between overall project costs and the costs for one section or a particular structure. Based on data made available by the cantons, the SFAO had to create a standardised basis in order to determine cost variance in the ten selected structures. In addition, the specific nature of the various trades interacting in a construction project makes it difficult to obtain an overall view of a project. In terms of project management, therefore, the data related to the finishings and the electrical engineering (ventilation, signage, monitoring installations, safety equipment) is always handled separately. Finally, the presentation of basic cost data differs from one project to another.

### **Insufficient traceability in cost variance**

The SFAO noted a lack of transparency and traceability in the cost development for the structures examined, despite the fact that these had been opened to traffic only recently or completed in 2009. The information on project documentation was often incomplete and of inconsistent quality, e.g. no project journal; simple reporting as the only means of keeping track of costs; some very short stage reports, with few or no explanations given for the way costs evolved during the project process. Frequently, cost variance is tracked on the initiative of the project owner, or even the main contractor (engineering firm). In 2001, FEDRO issued several project management directives specifying the main stages to be followed and the cost-related information that must be provided throughout the course of a project. However, the terminology applied here differs at times from that used in the SIA 103 professional standard, which also relates to project management. For the

structures studied by the SFAO, the project owner tended to follow the SIA standard. (Note that the planning stage, and in several cases even construction, started prior to 2001.)

### **Actual costs overrun estimates by an average of 20%**

Based on the ten sample projects, the final (inflation-adjusted) costs, i.e. real costs, came in at 77% to 187% of estimated costs (100%), with, on average, an increase of 20%. These are better results than in the international studies. On average, the price variation, in other words the actual inflation, represents 10% of the final costs for an underground structure. However, the SFAO found that the costs trend was not linear, i.e. costs may both increase and decrease between the approved project estimate, the awarding of contracts, the contract addenda and the final costs.

### **A sharp increase or decrease in costs at the awarding stage**

The difference between the estimate and the final costs is not the only indicator worth noting and, on its own, is not sufficient to gauge the standard of project management, particularly from a financial point of view. The greatest discrepancy in cost development occurs in the process of tender and awarding of contracts. The final bids vary between 58% and 165% of the estimates. For seven of the ten structures examined, the bids were lower than the estimates and, for three of these, much lower (some 40% less than the estimates). Even where bids are lower, however, modifications in the form of contract riders may still be made during the construction phase and have an impact on cost development. Between the bids and the final costs, cost variance lies between -12% and +88%, though generally upwards, with an average increase of 27%. In four cases, the increase was greater than 30%.

### **Cost of structures determined primarily by their size and complexity**

The cost per metre of road constructed (i.e. roads for traffic use) varies substantially, from between CHF 18,000 and 45,000, working out at an average of CHF 26,500. Two-way structures with an escape gallery are not necessarily more expensive. The short Roche Saint-Jean tunnel (211 m) is practically the most expensive (CHF 44,000) even though it has no specific safety equipment and no ventilation plant. The cost of the Kirchenwald tunnel stems from its highly complex nature (geometry and underground interchange). At CHF 37,000 per metre of road, the Uetliberg tunnel is relatively expensive; this is explained by its diameter (wider than the Aescher tunnel, for example) and the open-air sections along the tunnel tubes. The Opfikon case shows that renovating an existing motorway (widening from two to three lanes in each direction and motorway enclosure) is also relatively costly (CHF 22,000).

### **A wide range of reasons for cost variance, depending on the project**

According to the applicable standards, the degree of precision of the estimate should be no more than +/-10% of the final costs. Of the structures studied by the SFAO, five stayed within this guideline range, three exceeded the 110% mark, and two worked out at less than 90% of the final costs. The result depends to a large extent on the awarding phase, but variances may still occur in the course of execution. Incidentally, when the final costs are less than 90%, this does not necessarily mean that the project was well managed.

Although the awarding of contracts represents the main factor in cost variance, project changes or order modifications during execution form another major factor. Incidents that occur on-site during

boring or construction may also have financial implications. Practically all of the structures analysed by the SFAO were subject to project changes during execution, due to the need to apply new safety standards. These are external cost variance factors over which the project manager has only little influence. In five projects, changes were made to quantities or services without any actual project change, which may indicate a certain degree of inaccuracy in the original estimate. For one project, the work ultimately done did not correspond to the original project, which explains the sharp increase observed in costs. However, an incident during the execution phase does not necessarily generate a huge increase in costs: with sound risk management and anticipation, it is possible to rein in spiralling costs, even in the case of a relatively major incident.

### **Shortcomings in administrative and financial management**

In several cases there was clearly some confusion between the tracking and reporting of costs. Most of the time, costs management takes the form of simple reporting, at times quite brief. True cost controlling, showing the precise relationship between costs and services or costs and quantities, was rare. In the sample cases, the project manager often has sole responsibility for keeping track of costs during the execution of the work. This makes it quite difficult to get an overview of the entire project's finances, given e.g. the specific nature of the electrical engineering and the finishings and the fact that these two areas are managed separately.

What's more, it is often difficult to detect the basis for actual inflation used to take price variations into account, and inflation is not systematically entered, invoiced and deducted separately either.

In terms of financing, under the system in place until end-2007, FEDRO added a 15% supplement to the guarantee credit (based on the contracts). However, there were no guidelines as to when this 15% could be used, e.g. to finance any project modifications that may occur, to allow for inaccuracies in the estimate, or even inflation? In fact, the 15% supplement was simply a margin of manoeuvre for FEDRO without having to extend its credit line.

### **FEDRO regarded first and foremost as a technical support body**

FEDRO has focused on providing technical support to projects, ensuring that the technical standards are applied, particularly with regard to safety. Technical performance takes precedence over the financial aspect, something that is particularly evident from the absence of information on the final costs of a structure. In studying these ten structures, the SFAO very rarely came across documentation or indeed any other information on FEDRO's role and influence in project management or on cost development. It is thus difficult to say if and to what extent FEDRO was involved in the drafting of estimates, the awarding of contracts or when project changes were made. There are, of course, certain phases that require FEDRO's approval, but often this is a mere formality. In the projects examined, the SFAO did not find a trace of rejection by FEDRO. In one case, the basis for FEDRO's approval is not clear.

### **Changes in the right direction...**

Implementation of the new organisation of financial equalisation (RET) is bringing about profound change: since 1 January 2008, FEDRO has taken on full responsibility for the national roads network and now assumes the role of project owner, except for projects related to completing the network.

New directives have been adopted concerning project management and procedures as well as financial monitoring, financing rules and skills distribution. As the cornerstone to this new process,

the directive on investments controlling provides the basis for managing investments and project costs at the various phases. The margin of manoeuvre for financing has been cut to 10% and is no longer automatically granted.

In association with the implementation of the new fiscal equalisation system, the introduction of the investments controlling system TDCost has brought unquestionable progress. Using this new application, it is now possible to find out the precise cost of a motorway construction project and see how these costs have evolved throughout the various phases. Based on the standardised data, the system can give an overview of the entire project or of the individual items making up a project or structure. If such a system had existed in the past, it would have been much simpler to compare projects, and cost transparency would no doubt have been ensured.

**... but the impact will not be measurable until several years from now**

However, the impact of the new system can only really be appreciated after a structure has been designed and completed using the new processes. This will not be the case until around 2016, upon completion of the Roveredo tunnel (A13), the first major structure that is fully controlled by FEDRO and integrated into the TDCost system. To a certain extent, the Roveredo project is a pilot project for applying the new directives and the procedures generated by TDCost. Most of the structures currently under construction are still managed by the cantons.

**Room for improvement and recommendations**

The SFAO regards the introduction of the new directives on project management and investments controlling as a step in the right direction but believes that further improvements could still be made. There is much at stake, with the Swiss Confederation planning to continue building and renovating tunnels over the next few years, whether to relieve bottlenecks, extend the network or refurbish certain sections.

The SFAO sees room for improvement in the accuracy of costs management as well as in project management, the quality of estimates, risk management and the role of FEDRO in project approval. The SFAO thus has eight recommendations for FEDRO.

FEDRO has submitted statements to each recommendation, emphasizing that measures towards improvement of the situation have been taken or will be introduced in the near future. Despite some divergences, the federal office claims that the recommendations will be implemented by the end of 2010 and 2011, respectively. In view of the considerable financial expenses, the SFAO will keep an eye on FEDRO's efforts and willingness to implement the recommendations regarding its commitment to greater cost transparency. The statement of FEDRO can be found in annexe 9 of the report.

**Original text in French**