www.biswbis.pb.edu.pl

CIVIL AND ENVIRONMENTAL ENGINEERING 2 (2011) ISSN: 2081-3279 BUDOWNICTWO I INŻYNIERIA ŚRODOWISKA

NEW POSSIBILITIES IN VISUALIZATION OF PROJECT PLANS

Gabriella SZENIK*, Miklós HAJDU, Orsolya BOKOR

Szent István University, Ybl Miklós Faculty of Architecture and Civil Engineering,
Department of Construction Management, Budapest, Thököly út 74., H-1145

Abstract: The Gantt chart is the most widespread project planning method. Due to the development of project management applications, more and more data can be assigned to the project plan. The options for handling new information have changed the purpose of creating a Gantt chart in many aspects. Moreover, we would like to manage all data in one place in the planning and in the tracking phases as well. As a result new aspects of analysis could also be introduced.
In this paper, the Gantt chart is discussed from a brand-new point of view and novel methods are suggested in order to improve the management and understanding of the visual display.

keywords: evaluation lines, project management, scheduling, tracking, visualization.

1. Introduction

The most widespread way of displaying project plans is the Gantt chart. By using this, we are able to show visually where the activities are placed in time and the logical dependencies between them. In most cases only the data related to planning are displayed. Modern project management tools provide us with the opportunity of tracking and updating our projects. We can display these data in the Gantt chart as well. However, the evaluation based on the given information is a time-consuming task that requires close attention. In addition, a network consisting of thousands of activities could be hard to comprehend.

In this paper, we would like to introduce a new visualization method that offers an explicit display of activity, cost and resource data and ensures quick evaluation of the projects based on them. We have developed the system of evaluation lines by generalizing progress lines. We handle the data related to planning and tracking and their analysis separately.

2. Display of Project Plans

The Gantt chart, which was developed by Henry Gantt in 1910, is the most common way of displaying project plans. The method of network planning has improved to a significant extent in the past century. Today's modern network planning applications provide us with the opportunity of managing megaprojects of hundreds or thousands of activities. Applying the general methods for displaying these huge complex networks makes a full-scale review impossible when planning or tracking.

State-of-the-art tools offer more and more possibilities for the different representations of the distinct properties of the schedules. Nowadays it is an essential feature of them that more than one logical dependencies can be defined between activities, different type of tasks are marked by diverse colors, one activity can be indicated by more bars at the same time, and that more plan versions can be displayed.

By using computer programs that are suitable for design and tracking as well, the percentage of completion of the tasks in progress can be displayed too.

Figure 1 shows a schedule where the different types of logical relationships and activities are represented by distinct colors. There are maximal and minimal type, critical and non-critical dependencies, summary and non-summary, critical and non-critical and finished and in-progress tasks.

In case of linear projects, such as the construction of the sewage system, the cyclogram is a favored way of imaging the project in space and time at the same time. With the help of this method, the spatial contradictions can be avoided.

* Autor odpowiedzialny za korespondencję. E-mail: szenik.gabriella@ybl.szie.hu

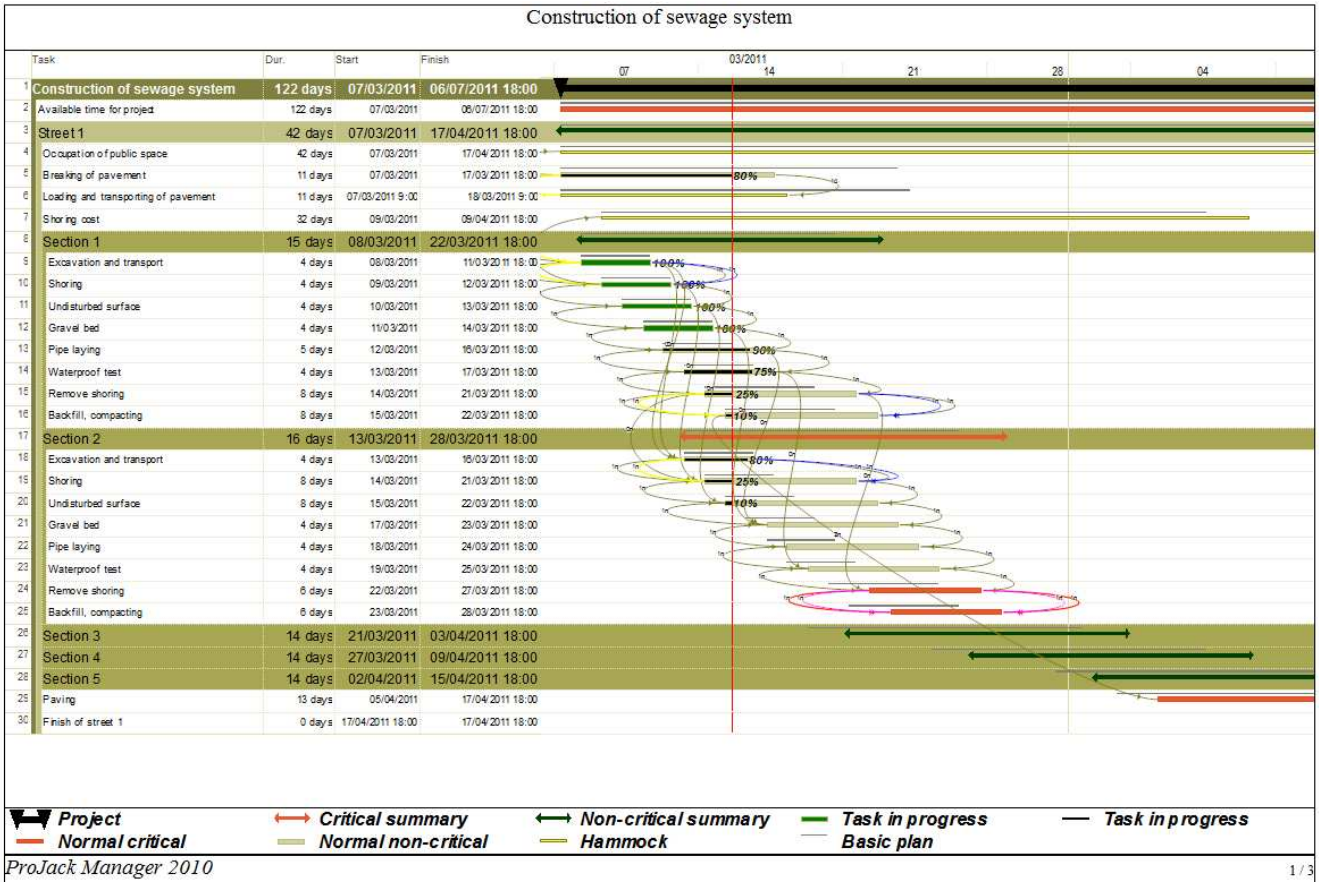


Fig. 1. Updated schedule.

3. System of Evaluation Lines

Owing to the development of the project planning tools, more and more data related to the activities can be managed. Reviewing and comprehending these is a very time-consuming task that requires close attention. When creating the system of evaluation lines, the Gantt chart and the method of progress lines served as a basis to work out a system that is fitted for the display of project data. Evaluation lines are applied to show the connection between the time and cost data of activities. An evaluation line is basically a polyline that should be read from top to bottom and is broken at each task (Hajdu, 2010).

The system of evaluation lines can be used for the analysis of the time and cost data of our projects both in the planning and in the realization phases.

The development of the system is in progress. The evaluation lines have been put into two categories: information serving to analyze time-type and cost-type data. Regarding the fact that current project planning programs have certain functions that can be used for the analysis of the time-type data, the examples below are such that can be demonstrated in network view by the already existing tools. Obviously, in order for the system to work properly, the programs should be developed. However, the functions necessary for examining cost-type data cannot be found in the project planning applications that we know of. Consequently, certain improvements are required in this field as well. As a result, when making the examples below, first the data was copied from the Gantt chart into a spreadsheet application and the diagrams necessary for the evaluation lines were created by that.

In the following chapters, the activity data needed for the demonstration of the application of the system will be introduced, and then the actual use will be shown through some examples.

4. Activity Data

4.1. Management of Time-type Data

Many conclusions can be drawn about the project from the time data calculated during scheduling. In the course of our work, the following time-type pieces of information were used:

- start and finish: the date of the scheduled start and finish of the activities;
- early start and early finish: the date of the earliest possible start and finish of activities, if the project duration cannot change;
- late start and late finish: the date of the latest possible start and finish of the activities, if the project duration cannot change;
- updated start and finish: the date of the actual start and finish of the tasks that have been finished or are in progress;
- date of update: the date of the survey of the activities;

– date of percent of completion: the date of the state according to the current percent of completion based on the activity's percent of completion and the date of update;
– date data of baseline plan: date data valid at an earlier plan version.

4.2. Management of Cost-type Data

Based on the cost and completion data, conclusions can be drawn concerning the cost-effectiveness of the project. In the course of our work, the following cost-type pieces of information were used (Kovalcsik, 2007):

– cost of own resources: the actual cost of the activity;
– contract price of activity: the price for which the activity is undertaken;
– BCWS – Budgeted Cost of Work Scheduled: the cost of the activity according to the plan for a given period of time;
– BCWP – Budgeted Cost of Work Performed: the cost of the activity according to the plan based on the given percent of completion at a given date;
– ACWP – Actual Cost of Work Performed: the sum actually spent on the activity until a given date;
– EAC – Estimate at Completion: the expected cost of the activity based on the given intensity.

5. Application of Evaluation Lines

5.1. Evaluation of Time-type Data

Based on the above-mentioned time-type data, different conclusions can be drawn during their analysis in distinct phases of the project. When creating the system of evaluation lines, three main categories were defined for the analysis of the time-type data:

1. showing the shortcomings of planning,
2. reports based on survey data,
3. showing the differences between plan versions.

5.1.1. Showing the Shortcomings of Planning

The shortcomings of planning are usually due to the fact that an insufficient number of or inadequate types of logical dependencies have been defined. Conclusions can be drawn based on the investigation of the scheduled, early and late dates. Two evaluation lines have been defined in Figure 2:

– the green one marks the early finish of the activities,
– the red one connects the late finish of the activities.

With the help of these lines, we can see when the individual tasks can be performed within the given project duration.

Too great difference between the early and late finishes can indicate inadequate planning. Figure 2 shows that most of the tasks can be performed almost anytime within the project duration. In cases like this, it is worth investigating the logical dependencies between those activities and their successors. In order to correct the mistakes, additional relationships are defined between certain tasks. Figure 3 shows the result of this action; the late finishes of the activities are closer to the early finishes. It can be concluded now based on the evaluation lines that there are not any shortcomings of planning resulting from an insufficient number of task dependencies.

Task	Dur.	Start	Finish
Construction of sewage system	**122 days**	**07/03/2011**	**06/07/2011 18:00**
Available time for project	122 days	07/03/2011	06/07/2011 18:00
Street 1	38 days	07/03/2011	13/04/2011 18:00
Occupation of public space	38 days	07/03/2011	13/04/2011 18:00
Breaking of pavement	11 days	07/03/2011	17/03/2011 18:00
Loading and transporting of pavement	11 days	07/03/2011 9:00	18/03/2011 9:00
Shoring cost	28 days	09/03/2011	05/04/2011 18:00
Section 1	15 days	08/03/2011	22/03/2011 18:00
Excavation and transport	4 days	08/03/2011	11/03/2011 18:00
Shoring	4 days	09/03/2011	12/03/2011 18:00
Undisturbed surface	4 days	10/03/2011	13/03/2011 18:00
Gravel bed	4 days	11/03/2011	14/03/2011 18:00
Pipe laying	5 days	12/03/2011	16/03/2011 18:00
Waterproof test	4 days	13/03/2011	17/03/2011 18:00
Remove shoring	8 days	14/03/2011	21/03/2011 18:00
Backfill, compacting	8 days	15/03/2011	22/03/2011 18:00
Section 2	15 days	13/03/2011	27/03/2011 18:00
Excavation and transport	4 days	13/03/2011	16/03/2011 18:00
Shoring	8 days	14/03/2011	21/03/2011 18:00
Undisturbed surface	8 days	15/03/2011	22/03/2011 18:00
Gravel bed	4 days	16/03/2011	23/03/2011 18:00
Pipe laying	4 days	17/03/2011	24/03/2011 18:00
Waterproof test	4 days	18/03/2011	25/03/2011 18:00
Remove shoring	6 days	19/03/2011	26/03/2011 18:00
Backfill, compacting	6 days	20/03/2011	27/03/2011 18:00

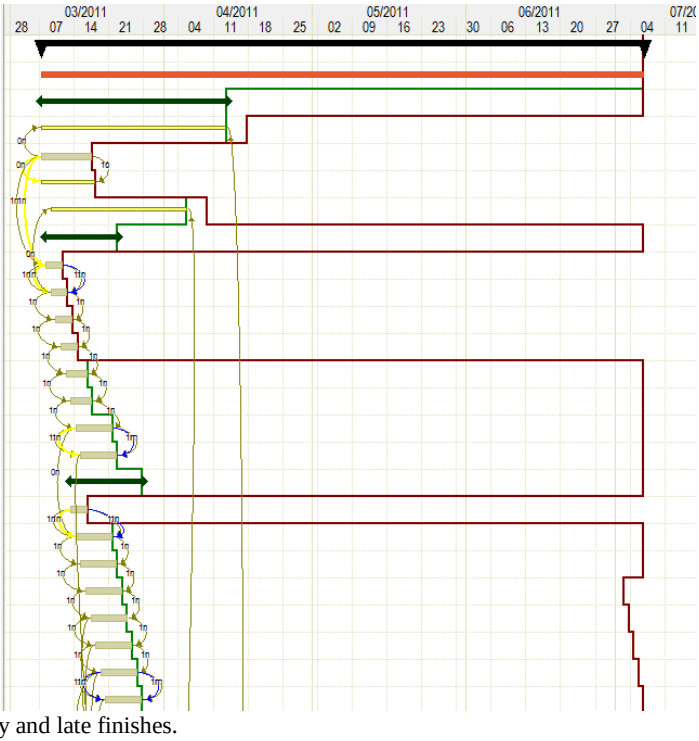
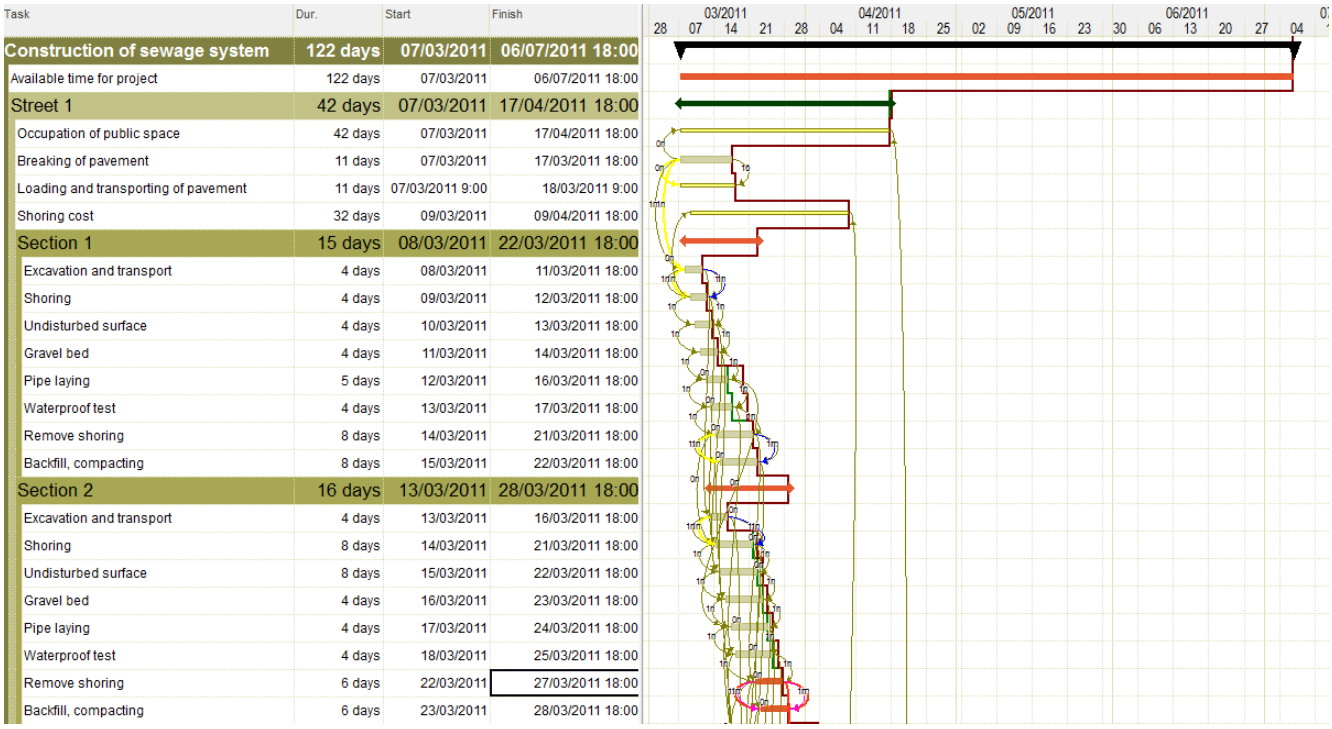


Fig. 2. Early and late finishes.



Task	Dur.	Start	Finish
Construction of sewage system	**122 days**	**07/03/2011**	**06/07/2011 18:00**
Available time for project	122 days	07/03/2011	06/07/2011 18:00
Street 1	**42 days**	**07/03/2011**	**17/04/2011 18:00**
Occupation of public space	42 days	07/03/2011	17/04/2011 18:00
Breaking of pavement	11 days	07/03/2011	17/03/2011 18:00
Loading and transporting of pavement	11 days	07/03/2011 9:00	18/03/2011 9:00
Shoring cost	32 days	09/03/2011	09/04/2011 18:00
Section 1	**15 days**	**08/03/2011**	**22/03/2011 18:00**
Excavation and transport	4 days	08/03/2011	11/03/2011 18:00
Shoring	4 days	09/03/2011	12/03/2011 18:00
Undisturbed surface	4 days	10/03/2011	13/03/2011 18:00
Gravel bed	4 days	11/03/2011	14/03/2011 18:00
Pipe laying	5 days	12/03/2011	16/03/2011 18:00
Waterproof test	4 days	13/03/2011	17/03/2011 18:00
Remove shoring	8 days	14/03/2011	21/03/2011 18:00
Backfill, compacting	8 days	15/03/2011	22/03/2011 18:00
Section 2	**16 days**	**13/03/2011**	**28/03/2011 18:00**
Excavation and transport	4 days	13/03/2011	16/03/2011 18:00
Shoring	8 days	14/03/2011	21/03/2011 18:00
Undisturbed surface	8 days	15/03/2011	22/03/2011 18:00
Gravel bed	4 days	16/03/2011	23/03/2011 18:00
Pipe laying	4 days	17/03/2011	24/03/2011 18:00
Waterproof test	4 days	18/03/2011	25/03/2011 18:00
Remove shoring	6 days	22/03/2011	27/03/2011 18:00
Backfill, compacting	6 days	23/03/2011	28/03/2011 18:00

Fig. 3. Early and late finishes after modifications.

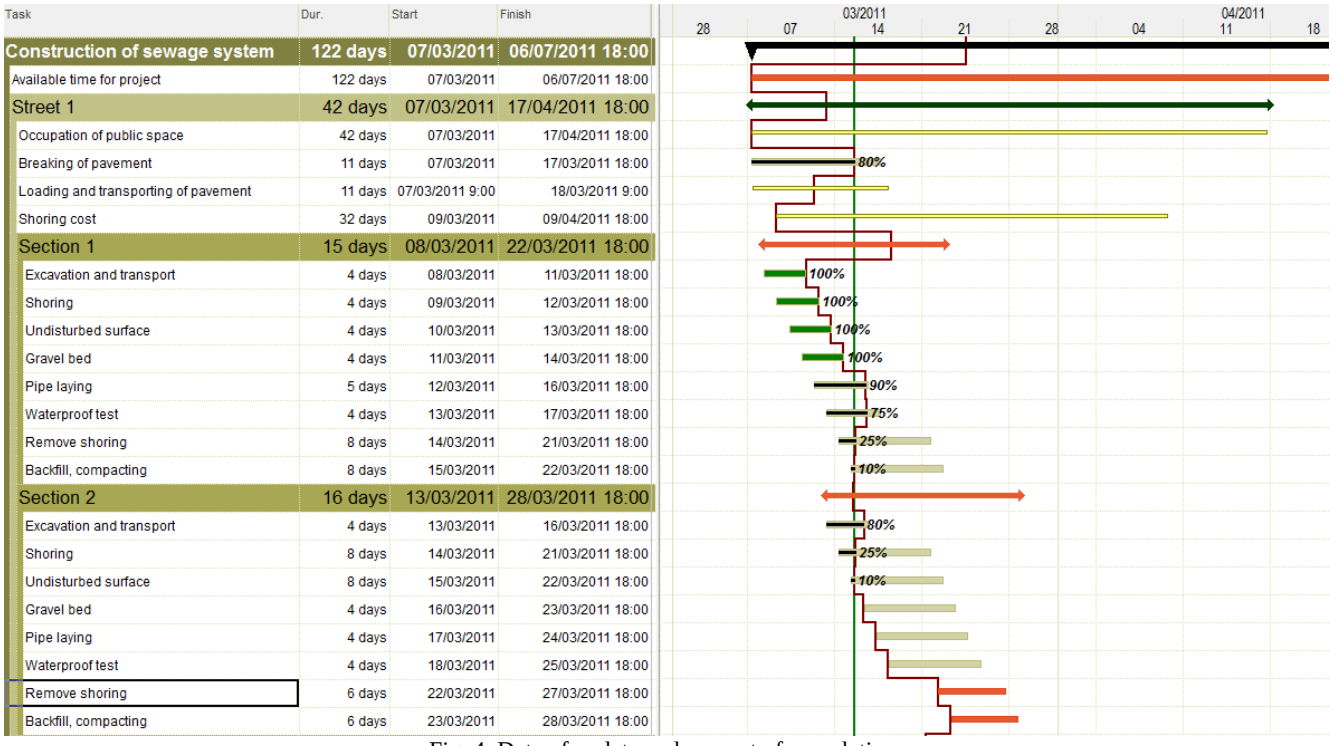
5.1.2. Reports Based on Survey Data

When making a survey, an actual picture of the project can be obtained contrasting to the schedule. It is expedient to examine how each task is progressing in comparison with what was scheduled before. Two evaluation lines have been defined in Figure 4:

– the green one marks the date of updating,
– the red one connects the date of percent of completion.

With the help of these two data, we are able to determine which activities are ahead of schedule and which one are lagging behind:

– if the date of the percent of completion is to the right of the date of update, the percent of completion is greater than scheduled; the task is ahead of schedule;
– if it is to the left, the percent of completion is less than scheduled; the task is lagging.



Task	Dur.	Start	Finish
Construction of sewage system	**122 days**	**07/03/2011**	**06/07/2011 18:00**
Available time for project	122 days	07/03/2011	06/07/2011 18:00
Street 1	**42 days**	**07/03/2011**	**17/04/2011 18:00**
Occupation of public space	42 days	07/03/2011	17/04/2011 18:00
Breaking of pavement	11 days	07/03/2011	17/03/2011 18:00
Loading and transporting of pavement	11 days	07/03/2011 9:00	18/03/2011 9:00
Shoring cost	32 days	09/03/2011	09/04/2011 18:00
Section 1	**15 days**	**08/03/2011**	**22/03/2011 18:00**
Excavation and transport	4 days	08/03/2011	11/03/2011 18:00
Shoring	4 days	09/03/2011	12/03/2011 18:00
Undisturbed surface	4 days	10/03/2011	13/03/2011 18:00
Gravel bed	4 days	11/03/2011	14/03/2011 18:00
Pipe laying	5 days	12/03/2011	16/03/2011 18:00
Waterproof test	4 days	13/03/2011	17/03/2011 18:00
Remove shoring	8 days	14/03/2011	21/03/2011 18:00
Backfill, compacting	8 days	15/03/2011	22/03/2011 18:00
Section 2	**16 days**	**13/03/2011**	**28/03/2011 18:00**
Excavation and transport	4 days	13/03/2011	16/03/2011 18:00
Shoring	8 days	14/03/2011	21/03/2011 18:00
Undisturbed surface	8 days	15/03/2011	22/03/2011 18:00
Gravel bed	4 days	16/03/2011	23/03/2011 18:00
Pipe laying	4 days	17/03/2011	24/03/2011 18:00
Waterproof test	4 days	18/03/2011	25/03/2011 18:00
Remove shoring	6 days	22/03/2011	27/03/2011 18:00
Backfill, compacting	6 days	23/03/2011	28/03/2011 18:00

Fig. 4. Date of update and percent of completion.

5.1.3. Showing the Differences between Plan Versions

In the lifetime of the project, many plan versions are produced. After the project plan is approved, it is worth saving the initial state as a so-called baseline plan. Moreover, it is wise to create another baseline plan, which will store the data of the actual state, after every update or before every plan modification. Therefore the difference between the plan versions can be shown in every phase of the project. The two evaluation lines defined in Figure 5 show these differences:

– the original starts (according to the baseline plan) are marked by the continuous green line, the finishes by the dashed green one;
– the starts that have been modified after the update are connected by a continuous, the finishes by a dashed red line.

By displaying the data of the baseline and the actual plan, we can demonstrate how the actual plan is doing in contrast with the original version. In case of those activities where the actual finish is after the baseline finish, we can state that there is a delay compared to the baseline plan.

5.2. Evaluation of Cost-type Data

By the investigation of the cost-type data mentioned in the previous chapter, the analysis of the differences between them is meant. Similar to the time-type data, the data that should be analyzed can be put into three groups:

1. showing the connection between the budgeted costs of activities
2. cost analysis based on survey data
3. showing the differences in cost between the plan versions.

5.2.1. Showing the Connection between the Budgeted Costs of Activities

When creating the project plan, more than one cost feature could be assigned to every task. Countless evaluation line can be defined to analyze these data together or one by one. Maybe the most important cost analysis can be seen in Figure 6. A two-colored evaluation line is defined for the analysis of the margins calculated based on the cost of the own resources and the contracted prices. Green marks the values to the right of the project margin (dashed blue line), and red the ones to the left. This way, we can easily see how the margin of each task relates to the project margin.

In order to get a fuller picture, the actual margin values are also displayed in addition to the margin percentages necessary for the evaluation line.

5.2.2. Cost Analysis Based on Survey Data

The updated schedule could generally be analyzed based on the budgeted costs of the original schedule (BCWS), on the budgeted costs calculated based on the given percent of completion (BCWP) and on the actual cost belonging to the given percent of completion (ACWP). The four most important variance indices are (Kovalcsik, 2007):

1. Cost variance (CV) shows the difference between the actual (ACWP) and the expected (BCWP) cost that belong to the given percent of completion.

$$CV = ACWP - BCWP \quad (1)$$

Task	Dur.	Start	Finish
Construction of sewage system	122 days	07/03/2011	06/07/2011 18:0
Available time for project	122 days	07/03/2011	06/07/2011 18:0
Street 1	42 days	07/03/2011	17/04/2011 18:0
Occupation of public space	42 days	07/03/2011	17/04/2011 18:0
Breaking of pavement	11 days	07/03/2011	17/03/2011 18:0
Loading and transporting of pavement	11 days	07/03/2011 9:00	18/03/2011 9:0
Shoring cost	32 days	09/03/2011	09/04/2011 18:0
Section 1	15 days	08/03/2011	22/03/2011 18:0
Excavation and transport	4 days	08/03/2011	11/03/2011 18:0
Shoring	4 days	09/03/2011	12/03/2011 18:0
Undisturbed surface	4 days	10/03/2011	13/03/2011 18:0
Gravel bed	4 days	11/03/2011	14/03/2011 18:0
Pipe laying	5 days	12/03/2011	16/03/2011 18:0
Waterproof test	4 days	13/03/2011	17/03/2011 18:0
Remove shoring	8 days	14/03/2011	21/03/2011 18:0
Backfill, compacting	8 days	15/03/2011	22/03/2011 18:0
Section 2	16 days	13/03/2011	28/03/2011 18:0
Excavation and transport	4 days	13/03/2011	16/03/20
Shoring	8 days	14/03/2011	21/03/20
Undisturbed surface	8 days	15/03/2011	23/03/20
Gravel bed	4 days	16/03/2011	24/03/20
Pipe laying	4 days	17/03/2011	25/03/20
Waterproof test	4 days	18/03/2011	26/03/20
Remove shoring	6 days	22/03/2011	27/03/2011 18:0
Backfill, compacting	6 days	23/03/2011	28/03/2011 18:0

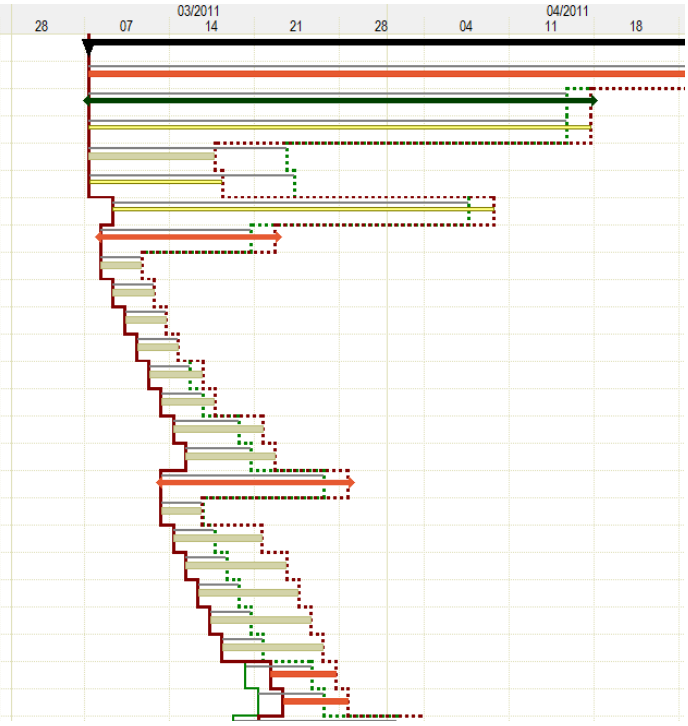


Fig. 5. Baseline and updated data.

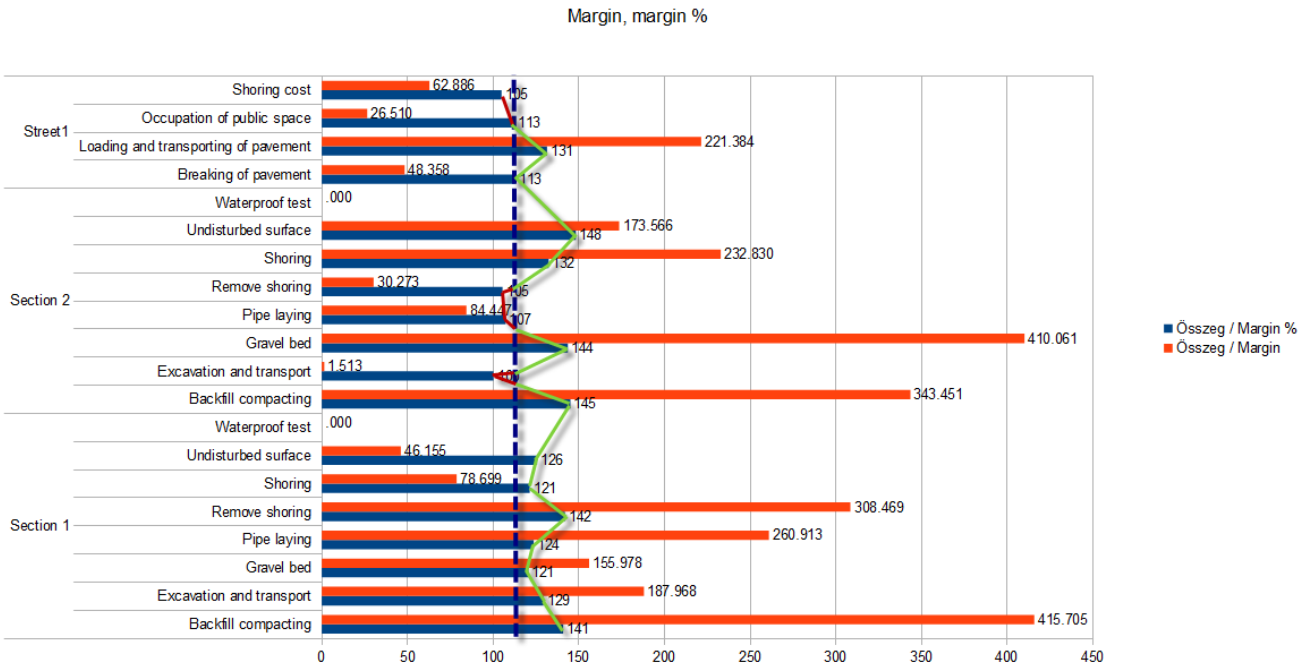


Fig. 6. Margins.

If the difference is a negative value, the actual cost is less than the budgeted, which means that money has been saved. Otherwise, in case of a positive CV, cost overrun has occurred.

2. Schedule variance (SV) shows the difference between the expected costs of the work actually completed (BCWP) and scheduled (BCWS).

$$SV = BCWP - BCWS \tag{2}$$

If the difference is a negative value, the actual percent of completion is less than scheduled, meaning that the task will probably finish later than scheduled. While in case of a positive SV value, earlier finish can be anticipated.

3. Actual Performance Index (API) shows the proportion of the actual (ACWP) and budgeted (BCWS) cost of an activity at a given date in percentages.

$$API = \frac{ACWP}{BCWS} \cdot 100\% \tag{3}$$

If API is greater than 100%, that means that the actual cost is higher than the expected based on the percent of completion, cost overrun can be anticipated. If the value is less than 100%, cost saving can be forecast.

4. Cost Performance Index (CPI) shows the proportion of the expected (BCWP) and actual cost (ACWP) of an activity at a given date in percentages.

$$CPI = \frac{BCWP}{ACWP} \cdot 100\% \tag{4}$$

If CPI is less than 100%, that means that actual cost is higher than it was scheduled until a given date, cost overrun can be predicted. If the value is more than 100%, cost saving can be anticipated concerning the given task.

The evaluation line defined based on the cost variance (CV) is displayed in Figure 7. It is marked with green in case of activities where the value is positive and red where it is negative.

5.2.3. Showing the Differences in Cost between Plan Versions

Similarly to the evaluation lines that can be defined in order to show the difference between the distinct plan versions based on the time-type data, we can draw lines to illustrate the changes with respect to the costs. By using these evaluation lines, we are able to draw conclusions about the cost factors of each plan version.

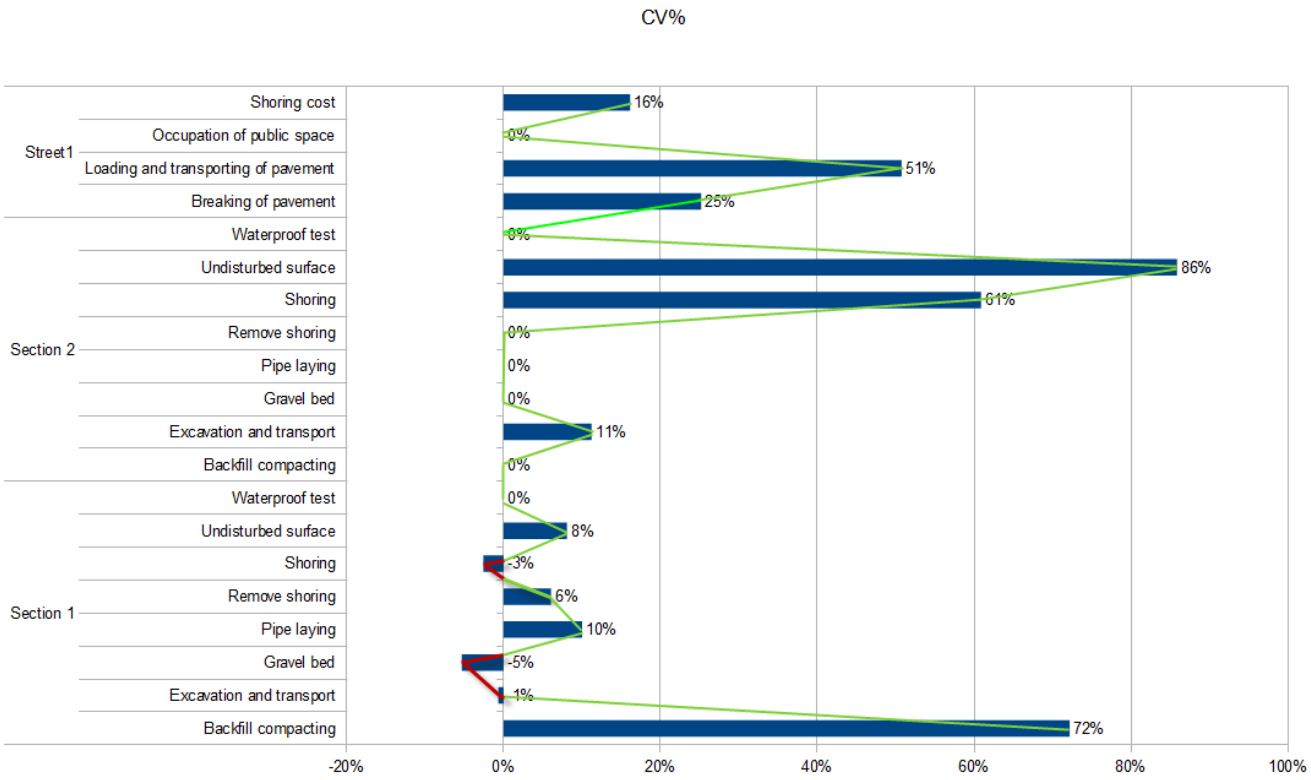


Fig. 7. CV%.

6. Conclusion

In the course of our work, our aim has always been to create a system that makes the full-scale visual display of project data possible. Dozens of evaluation lines in many categories can be defined during the lifetime of the project. They allow us to plan and analyze the data quickly and effectively.

References

Hajdu M. (2010). Projekttervek vizualizációja. *Építésmenedzsment és technológia konferencia*, 2010.

Kovalcsik G. (2007). MS Project 2007. *Computer Books*, 2010.