Scheduling Complete Review Application for Road Works

Michał Krzemiński*, Aleksandra Wypysiak

* Warsaw University of Technology, Faculty of Civil Engineering,IBE, Armii Ludowej 16, 00-637 Warsaw, Poland

Abstract

The article presents the problem of scheduling tasks on the example of scheduling road works. It presents the opportunity of using the total review method. The results show the fact that full optimization is not always possible to get. The results in question may not be fully satisfying, but it may be helpful.

Keywords: scheduling; construction scheduling; flow shop models.

1. Introduction

The scheduling issue is currently the subject of much research and study. This evolving field of knowledge is applied in many areas of industry and management [10, 11]. Scheduling algorithms are used in production processes, machines, operating systems, digital media, management systems and in the end the decision-making support systems [1, 2]. Interest in deterministic models presenting a theoretical basis for the scheduling associated with the development of technology and the increasingly higher excluding the human factor, and hence the uncertainty factor, in the field of production and decision-making systems. This way we come to one of the most important issues currently under review in the construction industry, the issues of the management of the implementation of the investment [10]. Planning is an integral part of the construction process. To a large extent this is a creative process to determine how to achieve the objective. The main effect is a timetable for implementing the project, in which time limits are given sequential tasks and resource allocation will be made. Scheduling in construction is a complex process due to the individual nature of each building. However, there is a type of construction production, which is reflected in the industrial production line [13]. These are the projects with flow shop scheduling models. Investments of this type are characterized by a clear breakdown on the part of (the plot) with the same technology. For this kind of projects include among others road works, which will be the subject of the following work. It should be noted that it is important to pursue the work on adaptation of industry models because they are often more refined.
The most common cause of this state of affairs is the amount of expenditure incurred on research activities for the industry [15].

2. Description of the road project

The subject of optimization is the schedule of the works developed for a part of Nowolazurowa Street in Warsaw. Road counts 3.6 km and leads from route Jerozolimskie to Połczyńska street. This is the road built in the class "M" (main street area) with two one-way roads two lanes each. Figure 1 shows the location of roads in the metropolitan area.

The objective will be implementation of the schedule for such processes as:
- Repair of paving the road with two lanes in each direction (milling texture and to put a new layer of SMA 0/8 according to the PN-S-3 cm thick 96025 and changing binding layer by cutting to a depth of 4 cm and recompose layer with BA 0/20 ACC. to PN-S-4 cm thick 96025)
- Total build/exchange of road infrastructure elements (stone and concrete curbs, walkways, bicycle paths and dehydration)

3. Road partition on the working plot

The road section was divided into 14 working plots of 9 repetitive jobs. When allocating an object on the land taken into consideration: the possibility of allocating the traffic difficulties arising out of the works and the area designated plots [4]. Although the effort failed to meet assumptions concerning the uniform size of the plots, but it is not a prerequisite and rarely manages to meet him because of the architecture and technology processes [14]. Striving to achieve the same surface plots is only allow getting continuity. Working time standards included in the time norm catalogues shall take into account the partly times of transition between the brigades working positions [3]. However, the distance between the sepals may be delaying work brigades and cause a discrepancy between the results of the analysis and the reality site. There is a possibility that the savings resulting from a ranking of plots can be absorbed in a significant way by the time you spend on transition brigades.
4. KASS v.2.0 program description

The Program used the following work is KASS v. 2.0 (Krzeminski Algorithm Scheduling System v.2.0). This is a program designed for a complete review scheduling method [7, 8]. Optimization schedule may be made using four criteria, they can be included together, in mutual dependencies or separately. Criteria, such as minimizing the time and the continuity of the working brigades are dedicated specifically to the needs of the construction and allow finding the optimal solution [6]. Progressive development of informatics and computer technique allows for more and faster and more accurate calculations, but a complete review method still requires large computational power and therefore has a limit in the number of entering data. The Program is able to perform quick and complete calculations for the 10 activities for 14 plots.

![Fig. 2. Starting window for KASS v.2.0 software.](image)

5. The scheduling criteria in KASS v. 2.0

The Program organizes the tasks according to four criteria [6]:

- The minimum time the most important optimization criterion from the point of view of the investor. Project should be completed in the shortest possible time to start to bring profits and do not absorb the costs associated with the construction and the maintenance.
- Minimum slack time of all work brigades. For developers it is important that construction crews employed had minimal downtime, so that their resources for their upkeep have been effectively used.
- Minimum slack time for chosen brigade. Often it is impossible to maintain the continuity of all the working brigades, then more important than reduce downtime all teams can be maintaining the continuity of the team with the greatest financial interest or.
- The minimum of brigade’s transition cost. If the working plot are arranged in a considerable distance from each other transition costs working brigades between them can cause more losses than profits derived from their ranking relative to other optimization criteria [5, 9].

The criteria used in the program allow you to optimize the schedule in a way that is the most obvious and best for construction purposes.
6. Scheduling in KASS v. 2.0

The review was conducted for two criteria, optimization criterion the minimum execution time and the continuity of the work brigades. The minimum transition brigades cost criterion between plots has been rejected due to the nature of the investment. A comparative analysis will be used to schedule standard, which is based primarily on the location of parcels. On the basis of this schedule shall be carried out a discussion of results concerning the advantage of minimizing the duration of the investment on the harmonious transition between the plots.

![Fig. 3. Scheduling in KASS according to the criterion of a minimum time.](image)

![Fig. 4. Scheduling in KASS according to the criterion of a minimum slack time for all brigades.](image)
7. Scheduling results in KASS v. 2.0

7.1. Introduction

In order to carry out the analysis of the results obtained was two schedules. One standard, featuring the line-up of plots in the order of approximately to the actual conduct of the works on the Nowolazurowa Street, the second reproduces the results of KASS v. 2.0. Two shifts working system with working hours: 7:00 to 13:00 and 14:00 to 20:00 from Monday to Saturday was established.

7.2. The criterion of a minimum time

The table shows the comparison of the durations for the standard schedule and schedule developed with the use of KASS. Figure following the table shows a bar chart, which illustrates the percentage of the difference of the results.

<table>
<thead>
<tr>
<th>Schedule</th>
<th>Durations [days]</th>
<th>Durations [hours]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard</td>
<td>248</td>
<td>2969</td>
</tr>
<tr>
<td>KASS</td>
<td>227</td>
<td>2719</td>
</tr>
<tr>
<td>Difference [%]</td>
<td>8,5</td>
<td>8,4</td>
</tr>
</tbody>
</table>

Fig. 5. Duration’s rates comparison.

7.3. The criterion of a minimum slack time for all brigades

The following table shows the results obtained in KASS for two criteria, minimum duration and maximum continuity, whether considered separately. Figure following table shows the graphical representation of the results.

<table>
<thead>
<tr>
<th>Criterion</th>
<th>Time [hours]</th>
<th>Slack time [hours]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum time</td>
<td>2719</td>
<td>9824</td>
</tr>
<tr>
<td>Minimum slack time</td>
<td>2754</td>
<td>7287</td>
</tr>
<tr>
<td>Difference [%]</td>
<td>1,3</td>
<td>25,8</td>
</tr>
</tbody>
</table>

Fig. 6. Rates comparison for total and slack time.
8. Conclusions

Presented paper shows the validity of scheduling methods in construction for work such as repair of urban street class M. In order to optimize the greatest possible to shorten the duration of the project using a complete review of scheduling the plots.

As part of an additional optimization was carried out according to the criterion of continuity of the work brigades with using KASS v.2.0 computer software. The Program allows you to find the optimal solution using the method a complete review with some limitations of entering data.

In order to assess the usefulness of this type of solution has two schedules, one using a ranking provided by the program, the second developed on the basis of an approximate, actual order plots. As a result of the scheduling saves time received 8.5%. This is a result that requires deeper analysis, mainly in financial terms. Works with such a large dispersion of the plots do not give a full picture of the use of this method. You may find that the cost of the brigade’s transition between the plots will absorb completely savings from optimization.

When it comes to optimizing work continuity of working brigades results are satisfying-by reducing the duration of the works of only 1.5% and minimalizing total slack time of 25%.

Scheduling methods for the construction industry are much more of a challenge than other areas of the industry. Undoubtedly, however, they are an opportunity to find the best solution possible. The results obtained in this work are the proof of the usefulness of the industry scheduling algorithms to optimize construction schedules.

References

[8] M. Krzemiński, Scheduling with using the KASS V.1.0, AUTOBUSY NR3/2013, ISSN 1509 - 5878, s.697 – 702.