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Study of Factors Influencing a Large Highway Construction Project: A System Dynamic Approach

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Abstract:

Highway construction projects in recent years in India have gained importance due to increased economic development and urbanization. This has resulted in increased highway construction to as much as 37% in 12th five-year plan. Due to the higher profit margins in the construction industry, many firms have entered the market, which has resulted in increased competition, which is forcing the construction firms to improve their process so as to gain maximum profitability.

Highway construction is a complex process which have influence of various engineering discipline on it because of its complexity and better understanding a System Dynamic approach is taken for this research paper, System Dynamic helps in understanding the working of complex problems that involve change over time.

The system Dynamic model developed in this research paper includes factors related to skilled labour, material delay and equipment failure. There is positive effect of factor skilled labour on project Average productivity and Work done, and factors material delay and equipment on time remaining.

Keywords: Highway construction, system dynamic, delay, average productivity

1. Introduction

Roads are an integral part of the transportation system. A country's road network should be efficient in order to maximize economic and social benefits. It plays a significant role in achieving national development and contributes to the overall performance and social functioning of the community.

Road construction can be compared to the arteries in a human body. Road network helps in facilitating conveyance of people, goods, raw material, etc. They help in increasing trade and thus country's economy. India's road network is the 3rd longest in the world with the length of about 3,320,410 km, after U.S.A. and China.

In India a study was conducted by the infrastructure and project monitoring division of the Ministry of Statistics and Programmed implementation in 2004. The findings from the study were that out of 646 central sector projects which had an overall cost of 2500 Cr, approximately 40% were behind schedule and delay ranged from 1 to 252 months. (Ravishankar, Anandkumar, Krishnamoorthy, 2014).

2. Literature Review

Highway construction is a complex process which have influence of various engineering discipline on it like Hydraulic engineering, Geotechnical engineering, Bridge engineering. SD modelling is a methodology used for understanding the working of complex problems that involve change over time. This academic discipline was created by Dr. Jay Forrester of MIT in 1960. SD modelling consists of multiple feedback loops and positive and negative feedback loop. Positive feedback loops generates growth while negative feedback loop generates equilibrium.

System dynamic modelling process has now been widely practised in the field of construction industry. Construction industry is the world's largest and also the most complex industry and also the greatest user of countries' resources (Michael J. Mawdesley, Saad Al-Jibauri, 2009). The construction of highways system consist of various subsystem like design workforce, material procurement, equipment procurement and construction procedure (S. Chritramara , S.O. Ogunlana, Bach 2002). These subsystems together are part of highway construction, but each system has their own problem. So when the highway construction system as a whole is considered these small problem of each system will create more complex problem for the project.

Because of such complexity of the highway construction process describe above we are using the SD approach to develop the model for these systems.

As the project grows complex and project failure rate increases due to cost and time overrun the traditional project management techniques are not enough and new and improved techniques are needed (Rodrigues A.,1997). Therefore, SD modelling and analysis will give better understanding of the highway construction project complexity. Simulation modelling will provide an important tool for understanding highway project behaviour under different condition and can give various policies which can help in reducing time and cost of the project.

There are various factors which influence the construction projects and different journal papers have different perceptions. These factors can be divided according to categories like design related, construction related, resources related, client related (S. Chritamara, S.O. Ogunlana, N.L. Bach (2002)) also there can be factors related to labour, contractor, owner, financial schedules, legal permission related (K.L.Ravishankar, Dr. S.AnandaKumar, V.Krishnamoorthy (2014)), but if we need to combine approximately all factor we can use Ishikawa fish bone diagram as shown below

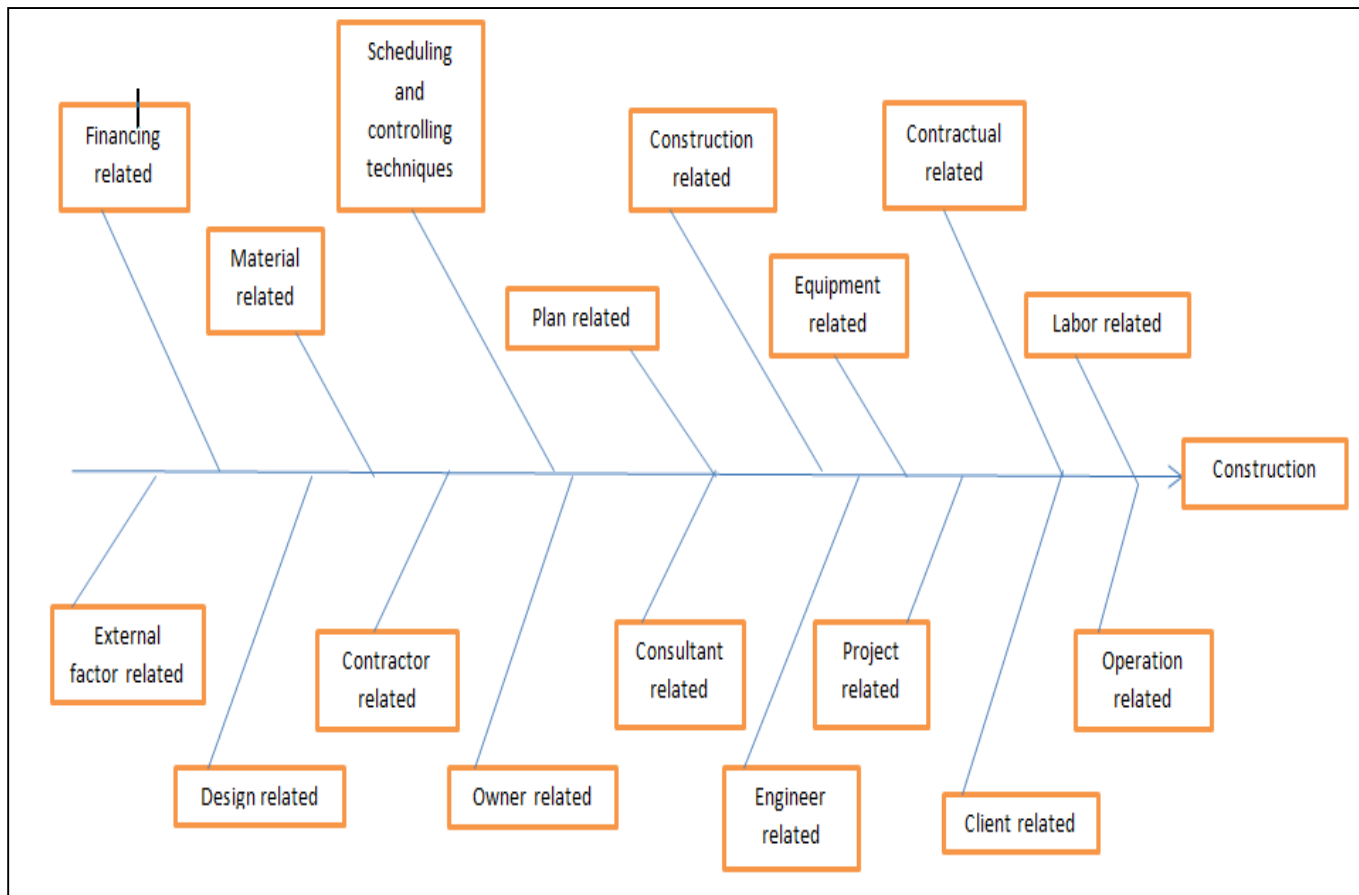


Figure 1: Fish bone diagram (Refrence : self)

As we can see there are various factors which affect the construction projects these factors can be finance related like low budget etc. or material related like low quality of material or there can be problems related to scheduling and controlling techniques then there are plan related technique like there are change in plans may be due to environmental factors and then there are construction related factor, equipment related factor, contractor or contractual related problems. There can be engineering related problems like problems in design or there can be problem with client with their satisfaction with the project also there can be problem with consultants of project or there can be problem with the project operation all these problems in the end will affect the construction projects.

3. Methodology

Typical Highway construction can be explained through the following flow diagram.

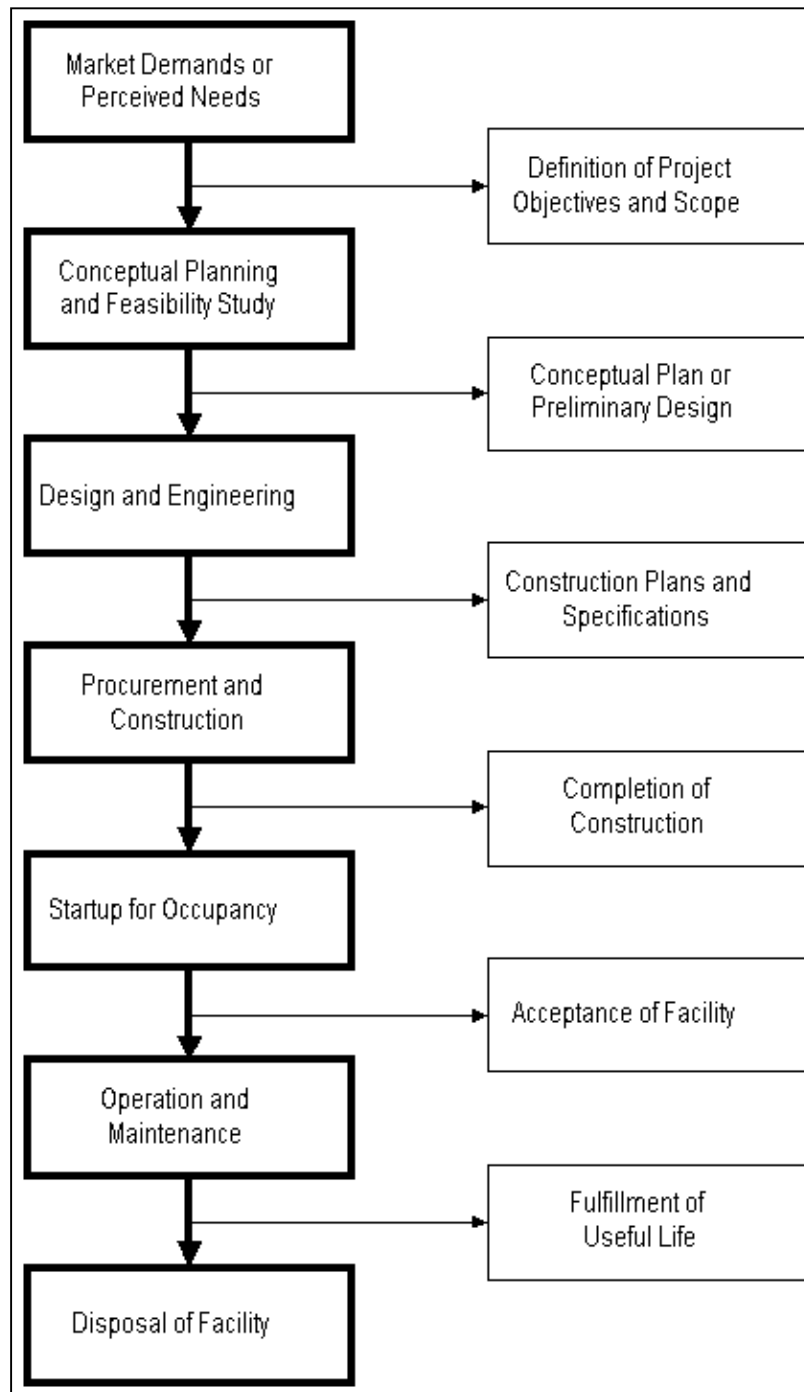


Figure 2: Typical highway construction flow diagram
 Source: google http://pmbook.ce.cmu.edu/IMAGES/fig1_1.gif

The SD model which will be considered for this project is shown below. This model is developed in Vensim software and it includes factors related to design workforce, quality of work, productivity rate, work to be done and rework to be done if there are changes in the projects. In this research paper a System Dynamic model is developed for determining the outcome for design and build highway construction project when factors related to labour type, factors related to permission from government departments and factors related to equipment failure and material delay are added. In the past research paper these factors were not considered and thus in this research paper an attempt is been made to see the changes these factors will bring. The added factors has shown changes in factors Average Productivity, Work Done, Staff Level. The SD model is shown below.

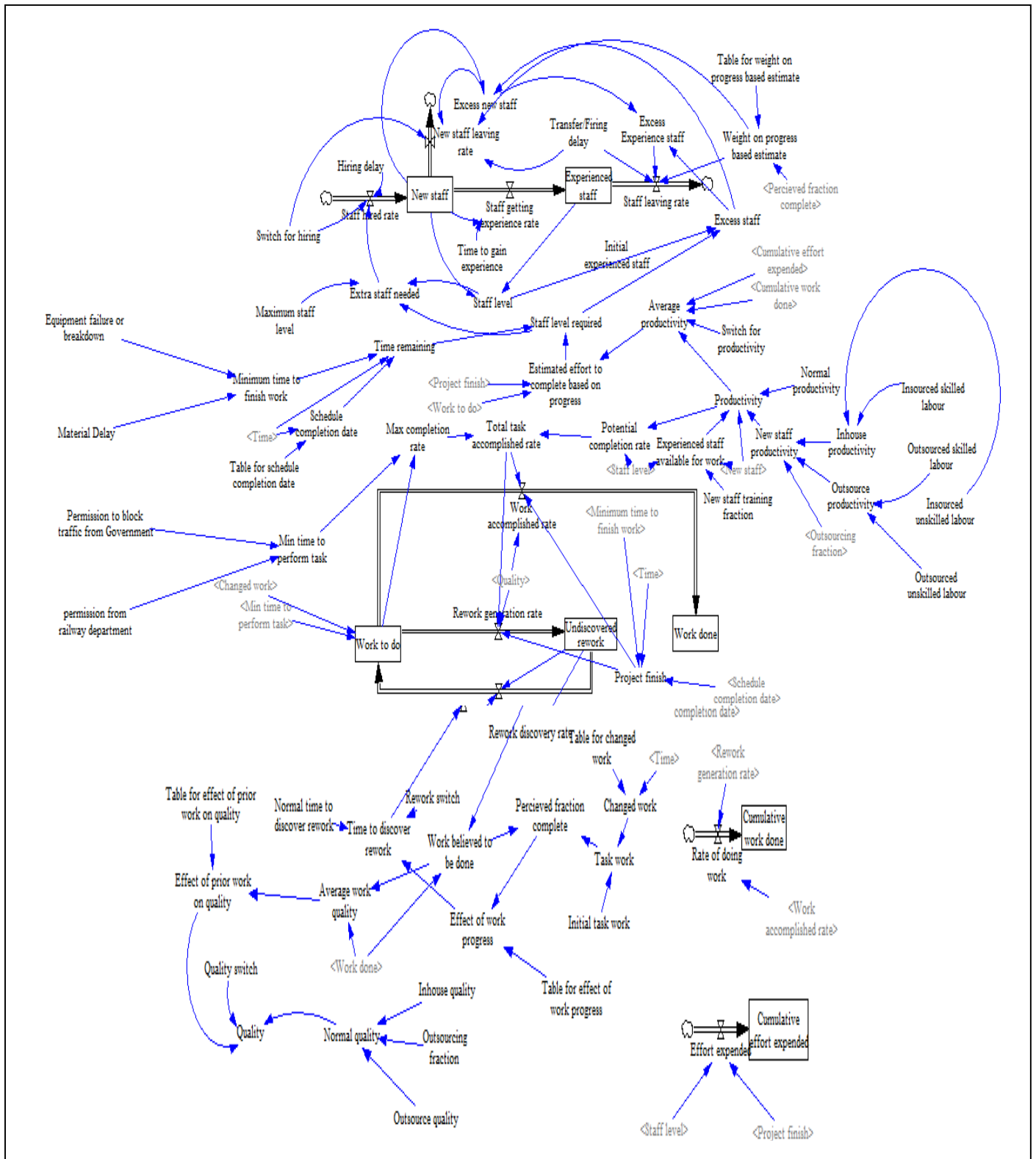


Figure 3: SD model showing factors affecting construction of large Highway Construction project. (Source Author)

4. Result

4.1. Average Productivity

The Average Productivity of the design and build highway construction projects increases as shown in the figure below as we can see if there are more skilled labour than the average productivity increases as number of task that can be finished in a day increased.

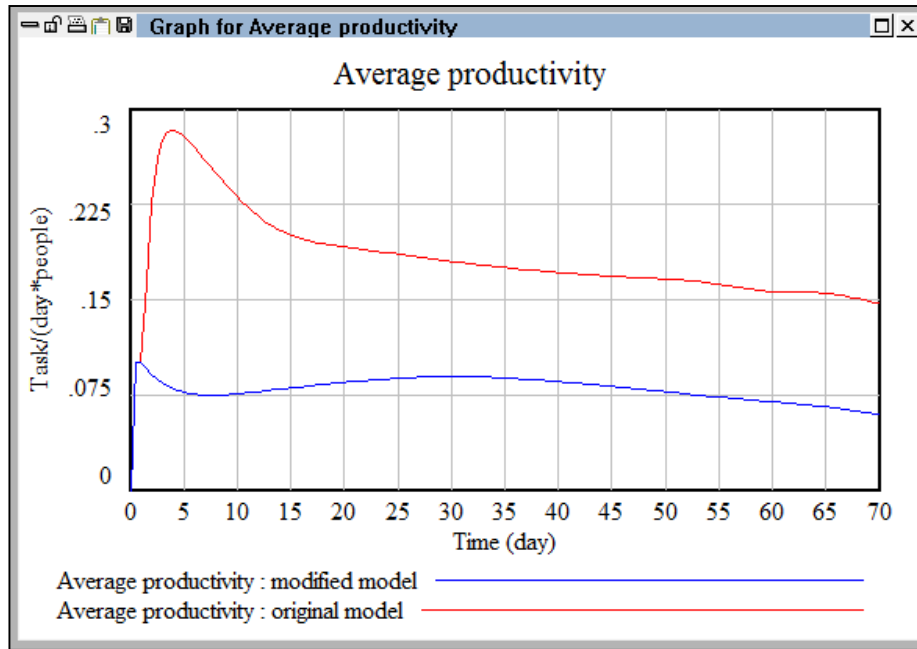


Figure 4: Average productivity for design and build highway project. (Source: Author)

4.2. Work Done

Considering figure 5, we can see that work done gets increased in the same time span when the number of skilled labours increased, even though the progress is slow but end result will give higher work done.

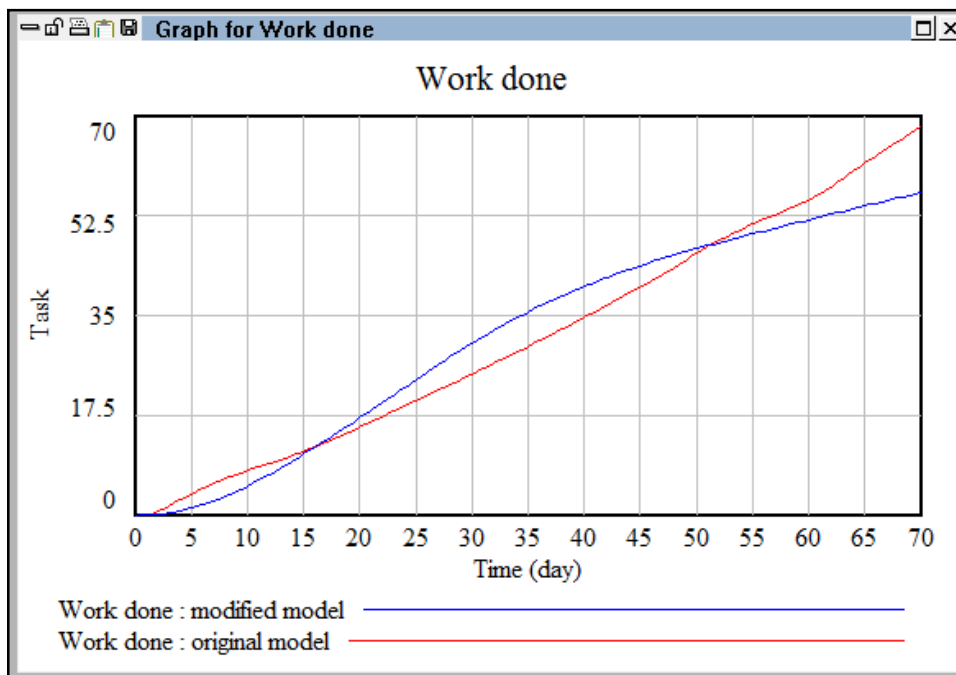


Figure 5: Work done for design and build Highway Construction Project. (Source: Author)

4.3. Time remaining

As we can see through figure 6, if there is delay in material supply or if there is equipment failure or if there is delay in getting permission from Government departments in getting permission then time remaining to complete the project will increase.

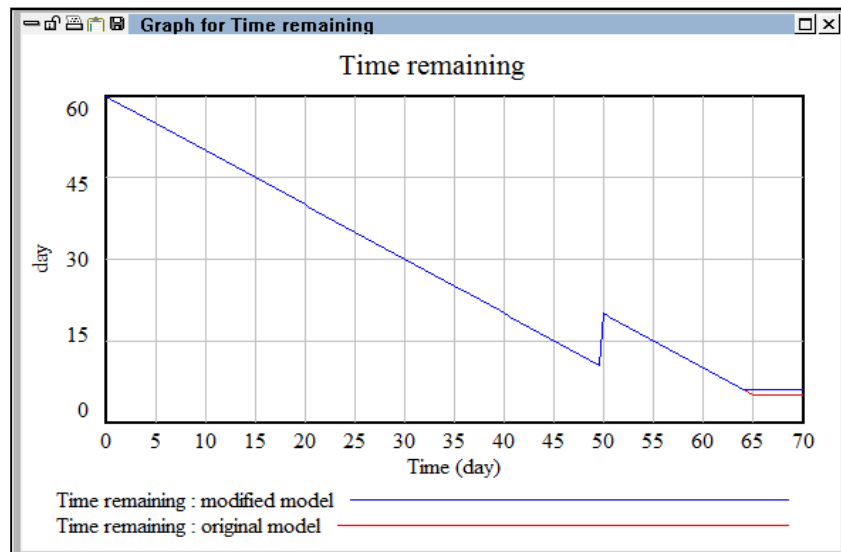


Figure 6: Time remaining to complete project in Design and Build construction project. (Source: Author)

5. Conclusion

There are many highway construction projects going on India. Also they experience the problem of cost and time overrun. The highway construction project of NH8 is also suffering the time overrun of about six months and cost overrun related to this time overrun because increase in time automatically increased the cost as machinery cost, labour cost and other project related cost are there.

Highway construction is a complex system and thus it have various stages involved, identifying the problems occur during construction process can help them to prevent them.

Through this project we have identified that if there are more skilled labours than average productivity of a project can be increased, also we can see that if there is equipment failure or delay in material supply or if there is delay from various Government departments in giving permission to block the traffic then the time remaining to finish the work will get increased.

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