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Optimizing Manpower Schedule Through Goal Programming Technique for XYZ Contractor Handling Multiple Construction Projects

Allyzza Nichole Velasco-Maranan[1], Ryan Jeffrey Curbano[2]

[1] *University of Batangas*
[2] *Lyceum of the Philippines University Laguna*
Email: [1]allyzzanichole.velasco@ub.edu.ph, [2]ryanjeffrey.curbano@lpulaguna.edu.ph

Abstract

Creating effective work schedule is a critical job for managers in both product and service oriented companies. According to Corson (2021), manpower scheduling in construction industry is a complex and time-consuming process due to the dynamic nature. This study strategically addressed the problem of putting the right people, right number of people, to right projects at the right time through optimizing the manpower scheduling using goal programming. The study used quantitative research as this is a systematic empirical investigation of observable phenomena through mathematical techniques. Since the proposed model contains multiple goals, this manpower scheduling problem was modeled using weighted goal programming with three goals with assigned priority. The formulated model, which contained 544 decision variables and 158 constraints, was tested in a XYZ Contractor handling multiple projects wherein the necessary data including manpower's expertise (worker performance) rating, number of projects, number of groups which was based on the number of shifts, and the required number of manpower for each project. OpenSolver was used to obtain the optimal solution in less than a minute. The results of the formulated model provided an optimal manpower schedule wherein the expertise or workers' performance were maximized and the deviations were minimized.

Keywords— Goal Programming, Manpower Scheduling, , Multiple Projects, Optimization

I. INTRODUCTION

Manpower scheduling problem is one of the challenges in the service industry such as staff scheduling for call centers and customer contact centers, nurse and physician scheduling with individual preference satisfaction, personnel scheduling for hotels, scheduling IT staff in a bank, shift scheduling of waiter and or waitresses in restaurants, security staff scheduling in different nature of business, airline crew scheduling, and scheduling of manpower in construction companies. It has become increasingly important due to the business becoming more service oriented and cost-conscious in a global environment. In a construction company, manpower scheduling process is a continuous process which involves reviewing the company's current manpower resource, forecasting future recruitment needs, and ensuring that the current manpower in both quantity and quality meet the needs of projects. Each construction tasks have several execution restrictions, conditions and requirements that must be considered which takes time to generate optimized manpower schedule for construction projects.

In the construction industry, contractors usually manage and execute multiple projects simultaneously which sometimes leading to sharing of resources such as materials, equipment, and manpower. The management of resources becomes a major challenge to project managers since they are aiming on optimizing number of different objectives which often conflict with one another. These objectives include duration, total project cost, profit, and resource variations.

The XYZ contractor is a new general contractor which started on the fourth quarter of 2017. The group has been involved in such projects from the different parts of the Philippines specifically in CALABARZON area. Their mission is to deliver excellent service and exemplary performance to achieve optimum customer satisfaction by providing superiority in quality and timely completed projects to continually improve their competencies. The contractor is still on the stage of process systematization to achieve those mission and vision. Major issue in XYZ contractor was 2 out of 4 projects experienced delay on project completion which leads to increase in labor cost and loss of profit. Such factors have been considered by the project manager during the analysis but the highest contributor that has been identified was the poor manpower scheduling. According to the project manager, balancing the allocation of manpower resource is very complex and time consuming. There are instances that some projects were overstaffing and some are understaffing, that's why it happens that they transfer manpower from one project to another which leads to confusion of workers, low-morale and missed performance goals.

The researcher identified that goal programming can be used to solve the complex issue that experienced by XYZ contractor. Goal programming is the best tool to create an optimal manpower schedule since the contractor has multiple goals. Most of the service oriented companies used goal programming to improve job satisfaction among workers such as the study of Rerkjirattikal, Huynh, Olapiriyakul and Supnithi (2020) and Kacmaz, Alakas and Eren (2019), as goal programming can also handle relatively large numbers of variables, constraints and objectives. This tool also aims to minimize deviational variables instead of directly maximizing profit and minimizing cost. XYZ contractor is more aiming to identify and satisfy the needs of each project in terms of manpower and their expertise. However, goal programming weakness is the ability of goal programming to produce solutions that are not Pareto efficient but such techniques can be used to convert the solution into the Pareto efficient.

The researcher conducted this study to generate an optimal manpower scheduling model for multiple construction projects easily. This research may help the construction companies to allocate the right number of manpower for each designated tasks and or projects while minimizing the labor cost, minimizing the projects duration while maximizing the manpower expertise without hindering the project schedule and ensuring equal distribution of workloads between the available manpower. Once XYZ contractor adopted the formulated model, the delay on project completion can be avoided and the target profit margin can be attained.

II. LITERATURE REVIEW

[1] According to Kashid and Jamgade (2019), nowadays, most of the construction projects were finished ahead of time because the project manager experienced some difficulties in finishing the project on time, within the budget and achieve other project objectives. Assessing progress, evaluation plans & corrective actions should be taken whenever required. These researchers concluded that time and cost were the major factors to be considered in the execution of projects. Optimization of construction projects is a systematic way to improve the profit margins and obtains best results under given circumstances.

[2] Meanwhile, in the study of Al-Rawi and Mukherjee (2019), labor Scheduling aim is to allocate the sufficient number of staffs for each designated task while minimizing Labor cost. Reconstruction of the schedule with available staff is usually simple, however changing the schedule may lead to adjustments to other Job schedules as well. This is the daily report of the requirement of different categories of manpower for a particular job to be done on a particular shift in a day in a construction company (1, 0) represents the availability of that particular manpower for a particular shift. 1

for a particular cell represents that the particular category of employee is required for a scheduled job and 0 represents non-requirement of the particular category of employee.

[3] Norwaziah Mahmud, Siti Hafawati Jamaluddin, Intan Syafina Hamidun, Nur Syuhada Muhammat Pazil (2018), identified crisis of large number of workers who suffered from stress at workplace due to the long working hours, inappropriate rest or leisure times and imbalance wages. Therefore, appropriate worker scheduling was organized to achieve satisfaction among all workers. The researchers proposed a model of Integer Goal Programming which intends to optimize the staff scheduling that are related to the staff requirements by the company and staff preferences. The objective function was to allocate staff to have balance work schedule at the optimal work hours thus, ensuring the employee satisfaction and efficiency of workloads. The model was optimized using one goal at a time such that the optimum value of a higher priority is never degraded by a lower priority. The result from this study gave optimum solution in which were supported by software LINGO and Excel based on the optimal staff schedule. Lastly, the pattern of scheduling rotated efficiently among the staff and each staff was working according to each schedule pattern. With the cyclical scheduling, it gives staff more control over their work life because they knew the type of shift schedule in future should have positive effect on their job satisfaction.

[4] K. Venkata Subbaiah, G. Daniel Vivek, Ch. Suresh (2015), conducted a case study about Optimization of Patrol Manpower Allocation Using Goal Programming Approach. The researchers identified that one of the most difficult tasks of the patrol administrators is allocation of manpower; i.e. determining the most effective level of operational manpower for patrol tasks. Typically, administrators resolve the allocation problem by relying on prior statistical data and by employing subjective analysis. In general, only limited systematic analyses have been applied to the problem. This study presents a non-linear goal programming model for allocating patrolmen to road segments within a patrol region. The model is demonstrated via a case example of the East section of Visakhapatnam. The formulation of the model of the problem involves in dentifying the goals and creating a priority structure to build the model. Hence, the formulation of the problem includes total patrolmen goal, total budget goal, minimum shift requirement goal, estimated accident reduction goal, accident rate reduction in high accident prone road segments goal and prioroty structure. The results of the model are valuable to the patrol administrator for considering departmental goals and priority structure, in addition to available historical data, in the assignment of patrol manpower for a given urban area.

[5] In the study of Varli (2019), devised the monthly working schedules of foremen working in the bearing sector by considering different scenarios. Goal programming was used as the method. Attempts were made to take the wishes of the formen into account with the least possible level of deviation. The shifts, days and sections used in the scenarios are the same. The different formen numbers are special constraints and goal constraints. In Varli and Eren studied the seniority levels of the workers in a factory using the Analytic Hierarchical Process (AHP) method. They then developed a model with goal programming to meet the number of employees needed for each shift and to make a distribution in a balanced and fair manner. Five goal constraints were used in the study. The same authors [29] aimed to ensure that the supervisory appointments of research assistants in the Faculty of Engineering of Kirikkale University were made in the most appropriate way during the final period. Goal programming was used as the method. Seventy four research assistants were assigned to 741 exams. They also discussed the staff scheduling problem for nurses working in the internal medicine and endocrine departments of a hospital. For the monthly schedule to be created, hospital rules and special permission

requests of the nurses were taken into consideration. Once again, the goal programming method was used. As a result of improvements and solutions, service quality is expected to increase.

[6] Bedir (2017) aimed at reducing production downtime costs from personnel at a hydroelectric power plant by suggesting the use of the 0-1 Priority goal programming model considering personnel competencies. Competencies may be prioritized with the PROMETHEE method. The criteria affecting personnel competences were weighted using the AHP method. As a result of the solution, an 86% improvement was achieved for August 2017, i.e., when the plant was operating most intensively.

III.METHODOLOGY

This study used quantitative research design. This method was used to conduct systematic empirical investigation of observable occurrences in the research locale through mathematical technique. Since the proposed model contains multiple goals, this manpower scheduling problem was modeled using weighted goal programming with three goals with assigned priority level. Goal programming is a branch of multiple objective optimization, which is a branch of multi-criteria decision analysis (MCDA). It is as an extension or generalization of linear programming to handle multiple, normally conflicting objective measures, since ILP is applicable only to single objective function. The objectives primarily contained deviational variables that represented a positive and negative deviation from each sub-goal and constraint. The objective function becomes the minimization of these deviations based on the relative importance or priority assigned.

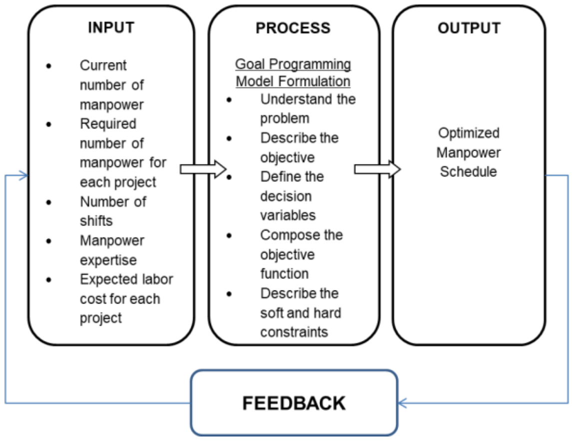

Figure 1. Research Paradigm

The researcher used Operations Research Modeling Approach in solving the problem relative to manpower scheduling that will satisfy XYZ Contractor. In this study, the researcher used the IPO (Input-Process-Output) model as a guide to generate an optimized manpower scheduling model through goal programming technique for multiple construction projects. The researcher identified the following requirements as an input, (1) current number of manpower, (2) required number of manpower for each project, (3) number of shifts, (4) manpower expertise, and (5) expected labor cost for each project, to formulate decision variables, objective functions and constraints. The researcher also considered the goal programming model formulation procedure by Rehman (2016); (1) identify the goals and constraints based on manpower availability, (2) determine the priority of each goals, (3) define the decision variables, (4) formulate the soft and hard constraints, (5) for each constraint, develop an equation by adding deviational variables d- i and d+ I, and (6) write the objective function in terms of minimizing a prioritized function of the deviational variables. After generating the model and testing empirically, the researcher is expecting to have an optimized manpower schedule output.

IV. RESULTS AND DISCUSSION

Problem Identification

XYZ contractor founds balancing the allocation of manpower resource very complex and time consuming, manpower expertise was not also considered in allocating each manpower resource to a certain project which then leads to delay of the project. There are instances that some projects' number of manpower exceed with the requirement and some are lacking, which leads to confusion of workers, low-morale and missed performance goals.

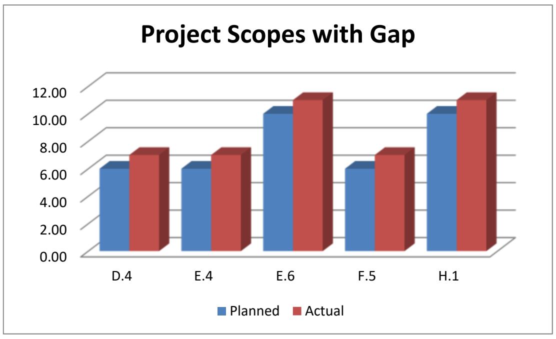

Figure 2. Project Scopes with Gap: Planned versus the Actual (Week)

Figure 2 shows the scopes of the project with gap. Out of 42 tasks, there are 5 tasks with gap that was identified. D.4, which is the pre-cast column installation, E.4 as reinforcement of concrete column, E.6, CHB reinforcement, F.5, column formworks and H.1, masonry works for CHB. It has been seen that most of the tasks were one-week delayed.

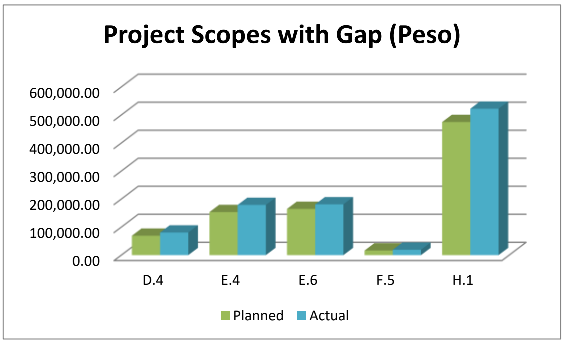

Figure 3. Project Scopes with Gap: Planned vs. Actual (Peso)

Figure 2 shows the scopes of the project with gap. Out of 42 tasks, there are 5 tasks with gap that was identified. D.4, which is the pre-cast column installation, E.4 as reinforcement of concrete column, E.6, CHB reinforcement, F.5, column formworks and H.1, masonry works for CHB. It has been seen that these tasks were out of the budget.

Assumptions:

The researcher used the following assumptions in modeling and solving the manpower schedule which is based on the data gathered from the XYZ contractor's project manager:

i. The contractor have two shifts with 8 hours for day shift (8:00am-5:00pm) and another 8 hours for night shift (8:pm-5:00am), which is represented by the researcher as "group" wherein the contractor can decide whether the allocated manpower of the model will be assigned as day shift or nightshift.
ii. Each manpower should maximize their expertise (first priority of the contractor), therefore deviation relative to this must be minimized.
iii. Minimum number of required manpower for each project must be satisfied (second priority of the contractor); therefore deviation relative to this must be satisfied.
iv. Deviation relative to target labor cost must be minimized (second priority of the contractor).
v. Each manpower is required to work at only one shift per day.

Notations:

The following notations are used to identify the model:

i = index for manpower
j = index for group (for each project)
xij = number of manpower i required for each group j
yij = indications if the particular group j was assigned to each manpower i
D1i+ = positive deviation for first goal priority
D1i- = negative deviation for first goal priority
D2i+ = positive deviation for second goal priority
D2i- = negative deviation for second goal priority
D3i+ = positive deviation for third goal priority
D3i- = negative deviation for third goal priority

Decision variables:

1 = if the manpower i is allocated to a group j of a project

0 = if the manpower i is not allocated to a group j of a project

Objective function:

The mathematical model considered three objectives which were weighed according to their priority such that (P1> P2> P3) for this study, but in general, it could be according to the decision-maker (Equation 1) which makes the model flexible.

$$minimize\ z = P_1 \sum_{i=1}^{I} (D_{1i}) + P_2 \sum_{i=1}^{I} (D_{2i+} + D_{2i-}) + P_3 \sum_{i=1}^{I} (D_{3i+} + D_{3i-})$$

Hard constraints:

The researcher recognized three hard constraints to satisfy the contractor's objectives in manpower scheduling. These are:

i. Required number of manpower i for Group 1 and 2 of Project 1 (Equation 2)

$$\sum_{i=1}^{I}\sum_{j=1}^{J} x_{ij} = 10$$

ii. Required number of manpower for Group 3 and 4 of Project 2; for Group 5 and 6 of Project 3; for Group 7 and 8 of Project 4; since these projects have same requirement (Equation 3)

$$\sum_{i=1}^{I}\sum_{j=1}^{J} x_{ij} = 8$$

iii. There should be at least one group j allocated to manpower i (Equation 4)

$$\sum_{i=1}^{I}\sum_{j=1}^{J} y_{ij} = 1$$

Soft constraints:

The mathematical model to optimized manpower scheduling using Goal programming The soft constraints were incorporated in the model as the goals which were formulated as follows:

i. Goal 1: This goal minimizes the deviation that maximizes the sum of manpower's expertise wherein D1i, is the amount of deviation from the maximum level of expertise of manpower. The level of expertise was given by XYZ contractor which is classified (ERij) from 1 - lowest until 10 – highest. TEi is the maximum expertise that could be obtained by manpower i.

$$\sum_{i=1}^{I} \sum_{j=1}^{J} ER_{ij} x_{ij} + D_{1i+} + D_{1i-} = TE_i$$

ii. Goal 2: This goal minimizes the deviations among the total number of manpower for each class which was based on their expertise i.e Class A which has the highest rating that ranges from 9-10 scores Class B which ranges from 7-8 scores, Class C which ranges from 5-6 and Class D which has the lowest rating that is 4 and below scores., Manpower 1-22 were classified as Class A, Manpower 23-35 were classified as Class B, Manpower 36-54 were classified as Class C, and Manpower 55-68 were classified as Class D. wherein D(2i+), and D(2i-) , are the amount of negative and positive deviations from the maximum total number of manpower i for assigned for each group j (TMi). These items were based on the civil engineer and or project engineer's estimates.

$$\sum_{i=1}^{I}\sum_{j=1}^{J} x_{ij} + D_{2i+} + D_{2i-} = \boldsymbol{TM}_{\mathbf{i}}$$

iii. Goal 3: This goal minimizes the deviations among the total labor cost for each class which was based on their expertise i.e Class A which has the rate of ₱570.00; Class B which has the rate of ₱550.00 , Class C which has the rate of ₱530.00 and Class D which has the rate of ₱500.00. Manpower 1-22 were classified as Class A, Manpower 23-35 were classified as Class B, Manpower 36-54 were classified as Class C, and Manpower 55-68 were classified as Class D. wherein D(2i+), and D(2i-) , are the amount of negative and positive deviations from the maximum total labor cost based on the rate of manpower i assigned for each group j (TCi). These items were based on the civil engineer and or project engineer's estimates.

$$\sum_{i=1}^{I}\sum_{j=1}^{J} x_{ij} + D_{3i+} + D_{3i-} = \boldsymbol{TC}_{\text{i}}$$

Empirical Testing

A case application was taken from a contractor to test the mathematical model. There were 4 ongoing multiple projects, with a total of 68 available manpower which were distributed based on each projects' size, wherein the project engineers experienced some delay in scheduling of manpower. The contractor also encountered some issues such as transferring of manpower that was already assigned to other projects in a particular day. However, the researcher identified that the contractor would like to achieve the following goals i.e (1) maximize the expertise of manpower by minimizing relative deviations, (2) minimize the deviation on the required number of manpower for each project still considering their expertise, and (3) minimize the deviation on the estimated labor cost for each project.

The following table shows the total number of decision variables in this study. However, due to the high number of decision variables i.e., 544 binary variables, the standard LP solver of MS Excel could not handle the model. Thus, the researcher considered to use OpenSolver. an Excel VBA add-in that extends Excel's built-in Solver with more powerful solvers. It is developed and maintained by Andrew Mason and students at the Engineering Science department, University of Auckland, NZ. Recent developments are courtesy of Jack Dunn at MIT. OpenSolver offers a range of solvers for use in Excel, including the excellent, Open Source, COIN-OR CBC optimization engine which can quickly solve large Linear and Integer problems.

The total decision variables for the experimental data is 544 binary variables i.e yij = 1, if manpower I was assigned in a group j of a project , 0, otherwise

The objective function used in the initial implementation is shown below with the following weights (1 for goal 1, 2 points for goal 2 and 3 point for goal 3) that considered the priority level among the three conflicting objectives. The goal's priority structure is like the study of Sen (2012) wherein priority levels were assigned to each goal in the mathematical model.

$$minimize\ z = 3\sum_{i=1}^{8}[(D_{1i})] + 2\sum_{i=1}^{8}[(D_{2i+} + D_{2i-})] + 1\sum_{i=1}^{8}[\frac{(D_{3i+} + D_{3i-})}{570} + \frac{(D_{3i+} + D_{3i-})}{550} + \frac{(D_{3i+} + D_{3i-})}{530} + \frac{(D_{3i+} + D_{3i-})}{500}]$$

In this case, the model used eighteen constraints. Figure 2 shows the screenshot of the use of Excel Solver and the OpenSolver add-in in this study. The figure also showed the model formulated that was used to solve the problem i.e decision variables, constraints, and objective function. The researcher calculated the solve time which is 2.49 seconds.

Table 1

Matrix of Expertise Rating (ER_{ij}) per Manpower

Manpower/Shift/Project	Expertise Rating
Manpower 1 – 22	10
Manpower 23 – 35	9
Manpower 36 – 54	8
Manpower 55 – 68	7

Table 1 shows the expertise rating of each manpower as evaluated by project engineers and foremen. It has been arranged in chronological order wherein manpower 1-22 has the highest rating and manpower 55-68 with the lowest rating

Table 2

Matrix of Salary Rate per Manpower

Manpower/Shift/Project	Salary Rate
Manpower 1 – 22	570
Manpower 23 – 35	550
Manpower 36 – 54	530
Manpower 55 – 68	500

Table 2 shows the salary rate of each manpower given by the contractor. It has been arranged in chronological order wherein manpower 1-22 has the highest salary rate and manpower 55-68 with the lowest salary rate.

Table 3

Matrix of Required Number of Manpower for each Project

	Project 1		Project 2		Project 3		Project 4	
	Group 1	*Group 2*	*Group 3*	*Group 4*	*Group 5*	*Group 6*	*Group 7*	*Group 8*
No. of Manpower	10	10	8	8	8	8	8	8

Table 4

Matrix of Required Number of Manpower for each Project Considering the Class

	Project 1		*Project 2*		*Project 3*		*Project 4*	
	Group *1*	Group *2*	Group *3*	Group *4*	Group *5*	Group *6*	Group *7*	Group *8*
Class A	3	3	2	2	2	2	2	2
Class B	3	3	2	2	2	2	2	2
Class C	2	2	2	2	2	2	2	2
Class D	2	2	2	2	2	2	2	2

Table 3 shows the required number of manpower for each project. The manpower that should be assigned for each group of each project should be equal. The project engineer can decide whether 1st group or 2nd group would be assigned as dayshift or nightshift. Meanwhile, Table 4 shows the required number of manpower for each group and project considering the level of expertise of each manpower.

Result Obtained from MS Excel Solver

	Project 1		Project 2		Project 3		Project 4	
Manpower/Group/ Project	Group 1	Group 2	Group 3	Group 4	Group 5	Group 6	Group 7	Group 8
Manpower 1	1	0	0	0	0	0	0	0
Manpower 2	1	0	0	0	0	0	0	0
Manpower 3	1	0	0	0	0	0	0	0
Manpower 4	1	0	0	0	0	0	0	0
Manpower 5	1	0	0	0	0	0	0	0
Manpower 6	1	0	0	0	0	0	0	0
Manpower 7	1	0	0	0	0	0	0	0
Manpower 8	1	0	0	0	0	0	0	0
Manpower 9	1	0	0	0	0	0	0	0
Manpower 10	1	0	0	0	0	0	0	0
Manpower 11	0	1	0	0	0	0	0	0
Manpower 12	0	1	0	0	0	0	0	0
Manpower 13	0	0	1	0	0	0	0	0
Manpower 14	0	0	0	1	0	0	0	0
Manpower 15	0	0	0	0	1	0	0	0
Manpower 16	0	0	0	0	0	0	1	0
Manpower 17	0	0	0	0	0	0	0	1
Manpower 18	0	0	0	0	0	1	0	0
Manpower 19	0	1	0	0	0	0	0	0
Manpower 20	0	1	0	0	0	0	0	0
Manpower 21	0	0	0	0	0	0	1	0
Manpower 22	0	1	0	0	0	0	0	0
Manpower 23	0	1	0	0	0	0	0	0
Manpower 24	0	1	0	0	0	0	0	0
Manpower 25	0	0	1	0	0	0	0	0
Manpower 26	0	0	0	1	0	0	0	0
Manpower 27	0	0	1	0	0	0	0	0
Manpower 28	0	0	1	0	0	0	0	0
Manpower 29	0	0	1	0	0	0	0	0
Manpower 30	0	0	0	0	0	1	0	0
Manpower 31	0	0	0	0	0	1	0	0
Manpower 32	0	0	0	0	0	1	0	0
Manpower 33	0	1	0	0	0	0	0	0
Manpower 34	0	1	0	0	0	0	0	0
Manpower 35	0	1	0	0	0	0	0	0
Manpower 36	0	0	0	0	0	1	0	0
Manpower 37	0	0	0	0	0	1	0	0
Manpower 38	0	0	0	0	0	1	0	0
Manpower 39	0	0	1	0	0	0	0	0
Manpower 40	0	0	1	0	0	0	0	0
Manpower 41	0	0	1	0	0	0	0	0
Manpower 42	0	0	0	1	0	0	0	0
Manpower 43	0	0	0	1	0	0	0	0
Manpower 44	0	0	0	1	0	0	0	0
Manpower 45	0	0	0	1	0	0	0	0

The model produced deviations equal to 0 and 1 in manpower and group of the project, respectively. It means that the model was effective in targeting the three goals simultaneously.

Overall, the results of the model showed improvement in maximizing manpower expertise and minimizing deviations from total number of manpower to be assigned in a group of a project considering the required number of manpower for each class based on their expertise. The result also minimized the deviation of the total labor cost based from the calculated budget of XYZ Contractor.

Validation

To check the optimality of the results, the researcher then compared the current allocation of manpower resource used by XYZ contractor to the simulated allocation using the model and system that has been formulated,

The researcher used the objective function that has been formulated to validate the optimality:

$$minimize\ z = 3\sum_{i=1}^{8}[(D_{1i})] + 2\sum_{i=1}^{8}[(D_{2i+} + D_{2i-})]$$
$$+ 1\sum_{i=1}^{8}[\frac{(D_{3i+} + D_{3i-})}{570} + \frac{(D_{3i+} + D_{3i-})}{550} + \frac{(D_{3i+} + D_{3i-})}{530}$$
$$+ \frac{(D_{3i+} + D_{3i-})}{500}]$$

Optimality of the Model Formulation using Goal Programming

Current Allocation		Result using the Model	
Weight	Goal	Weight	Goal
3	2.9375	3	2.5625
2	7.25	2	4.25
1	7.25	1	4.1875
Total	30.5625	Total	20.375

Since the project manager of XYZ contractor had identified that poor manpower scheduling was the true cause of increasing cost that leads to loss of profit, the researcher simulated the possible cost-benefit of the model formulated using goal programming.

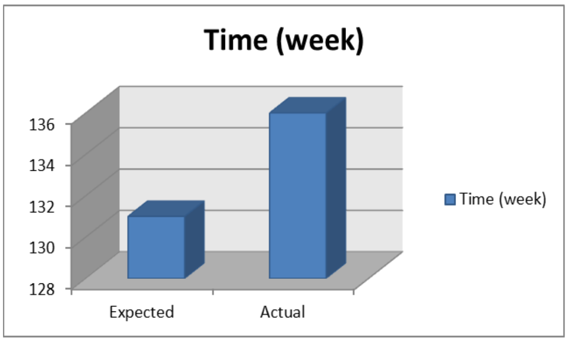

Figure 4. Project Completion Comparison in terms of Week

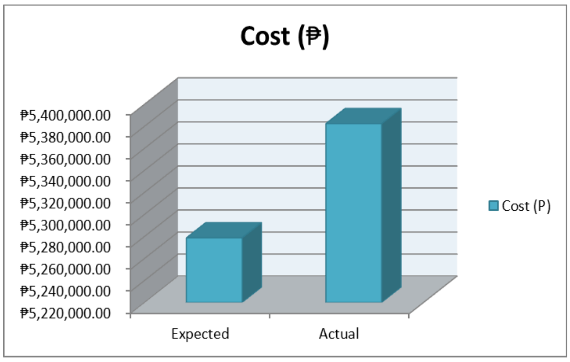

Figure 5. Project Cost Comparison in terms of Peso

Figure shows the comparison of the planned and actual project completion time in terms of week and Figure shows the comparison of project cost. It has been shown that the project was completed 5 weeks late based on the plan/estimate. It has also been shown that there was a difference of ₱103,746.66 project cost between the planned and the actual.

V. CONCLUSION AND RECOMMENDATION

Conclusion

a) The researcher identified the current condition of manpower scheduling of XYZ contractor. It was found that the contractor recognized that balancing the allocation of manpower resource was very complex and time consuming. The researcher also recognized that manpower expertise was not also considered in allocating each manpower resource to a certain project which then leads to delay of the project. There are instances that some projects' number of manpower exceed with the requirement and some are lacking, which leads to confusion of workers, low-morale and missed performance goals.

b) The researcher developed the decision variables needed for manpower scheduling that is 1 if the manpower i is allocated to a group j of a project, and 0 if the manpower i is not allocated to a group j of a project. The researcher recognized three hard constraints to satisfy the contractor's objectives in manpower scheduling. The total decision variables for the experimental data is 544 binary variables i.e yij = 1, if manpower I was assigned in a group j of a project , 0, otherwise

c) The mathematical model that was developed to optimized manpower scheduling using goal programming. The soft constraints were incorporated by the researcher in the model as the goals which can be summarized as follows: (1) minimizes the deviation that maximizes the sum of manpower's expertise; (2) minimizes the deviations among the total number of manpower for each class which was based on their expertise, and (3) minimizes the deviations among the total labor cost for each class which was based on their expertise. These three goals were weighed according to their priority such that (P1> P2> P3) for this study, but in general, it could be according to the decision-maker which makes the model flexible.

d) The manpower scheduling system for handling multiple projects was then developed by the researcher using the formulated model. The model produced deviations equal to 0 and 1 in manpower and group of the project, respectively. It means that the model was effective in targeting the three goals simultaneously. This model showed improvement in maximizing manpower expertise and minimizing deviations from total number of manpower to be assigned in a group of a project considering the required number of manpower for each class based on their expertise. The result also minimized the deviation of the total labor cost based from the calculated budget of XYZ Contractor.

e) The researcher used the objective function that has been formulated to validate the optimality: Using the assigned weights which was based on the given priority, there was a difference between the current allocation and allocation using the model formulated. Based on the calculation, the objective has been achieved, it has been minimized to 20.375 from 30.5625.

f) The researcher evaluated the cost-benefit of the result. Based on the comparison of the planned and actual project completion time in terms of week and project cost, it has been shown that the project was completed 5 weeks late based on the plan/estimate. It has also been shown that there was a difference of ₱103,746.66 project cost between the planned and the actual.

Recommendation

For better implementation of the model formulated using goal programming, the researcher recommended the following:

a) XYZ contractor should implement the model/system to achieve the organizational goals such as minimizing cost and finishing the projects on-time for them to maximize their profit.

b) XYZ contractor may purchase an excel solver extension software for better result of the model.

c) The contractor should implement a standard procedure for manpower estimation, so newly hired civil engineers/estimator will adopt the same process and variation can be eliminated.

d) The contractor should implement standard shift scheduling to avoid manpower confusion and low morale.

For future researchers, the researcher recommends incorporate other formulations in this model to a timetabling integer/goal/linear programming model that assigned manpower and the specific schedule since it was not included in this study.

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