IMPROVING EFFICIENCY WITHIN THE CONSTRUCTION INDUSTRY

ROLE PLAYING OR PLAYING WITH ROLES? A CASE STUDY OF WOMEN IN THE WORKFORCE DURING WORLD WAR II

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By
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On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

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The construction industry is a very complex and intricate system of players which requires the cooperation and communication of all involved parties to produce a successful end project. This would entail one which is within budget, within schedule, and of high quality. With all of the moving pieces this line of work entails, delays and disruptions within project schedules are close to unavoidable. Examples of delays that cause inefficiency include: shifts in the construction season, availability of resources, manpower levels and distribution, staffing, crew size, and sequencing of work (Trauner, Manginelli, Lowe, Nagata, & Furniss, 2009, pp. 206-208). With over 25 years of industry experience, Keane and Caletka (2015) state how analyzing these delays are important as "delay analysis… satisf[ies] the causation requirement in such a way that it can be used to assess the resulting damages" (p. 73). Employing Delay Analysis Techniques (DATs) to previous projects is crucial to understand the effect each delay caused on the overall project completion time, total budgeted cost, or both. In doing so, similar delays can be mitigated in the future, minimizing time and cost overruns. The technical research aims to identify delays within the construction industry to create an inclusive guideline for companies to engage with in order to generate project plans and schedules with greater efficiency for future endeavors.

In order to adequately understand and improve the efficiency of the construction workforce through its performance indicators seen today, a comparison to the model of the diverse workforce during World War II (WWII) will be used as the STS topic. During WWII, author/editor Fowle (1992) for the US Army Corps of Engineers detailed how crucial civil engineering projects were underway, such as "maintain[ing] navigable waterways, help[ing] control floods, and provid[ing] hydropower" (p. 3). Notable writer Horne (2019) stated that of these projects, at the beginning of the war in 1941, an estimated six million women joined the

labor force, completing these jobs which were previously closed off to them. Through this tightly coupled STS research, the focus will be on the extent of women's roles, and will answer the question of how their performance in construction/civil engineering industries were evaluated during that time. Additionally, this research will evaluate the presence of gender inequality within the workforce, as this time period is notably one of the first periods where women were widely present in more technical industries. In present day, there is ongoing controversy within these fields regarding the lack of diversity and inclusivity of its workforce. By comparing this historical model to the present industry, the root cause of these discriminations may be identified, allowing information to then be provided to combat these discerning stereotypes.

The technical research of improving efficiency within the construction industry will be conducted with a group of fellow students: Vivian Austin, Caroline O'Keeffe, and Diyar Rashid from the department of Civil Engineering, and Zachary McLane from the department of Engineering Systems and Environment. Our project will be completed under the guidance of our technical advisors, Professor Arsalan Heydarian and Professor Diana Duran of Engineering Systems and Environment. Finally, our technical work is centralized around historical data we have received from our corporate sponsor, general contractor Hourigan. Todd Bagwell, Vice President of Preconstruction Services, is our main point of contact for them. Figure 1 shown on the next page specifies the anticipated timeline of the project work, concerning both the technical and STS research aspects.

Parse data from Hourigan	10/30 -11/21
STS research	10/30 – 1/20
Conduct delay analysis using software Primavera P6	11/22 – 1/21
STS report	11/22 - 3/20
Guideline handbook deliverable to Hourigan	1/22 – 4/1
SIEDS Conference paper	April (TBD)

Figure 1: Project Timetable. This figure shows the anticipated dates the main aspects of the Capstone project will be completed. (Zimmerman, 2020).

This table is a mere estimate of how long each aspect of the project should take, however dates may be adjusted to fit the actual work duration accordingly.

IMPROVING EFFICIENCY WITHIN THE CONSTRUCTION INDUSTRY

Delays within the construction industry can be detrimental to numerous players involved. The owners/investors can lose large sums of money; the subcontractors could lose a good relationship with a general contractor due to lag in equipment delivery; an architect could lose his/her licensing etc. Arbitrator and adjudicator Burr (2018) brought attention to the grand significance of delays, as research from 2002 revealed 58% of construction projects had a later date of completion than expected, and 50% of projects were over budget (p. 13). Exemplary project planning and scheduling is imperative to ensure that a basic level of efficiency is met within the project. Although planning and scheduling sounds relatively like the same task, internationally renowned author and educator, Mubarak (2015), detailed the difference between the two, stating how project planning focuses on “functions, such as cost estimating… project control, quality control, safety management, and others,” whereas scheduling “is the

determination of timing and sequence of operations" (p. 4). Ensuring these methods are performed correctly is crucial, as there are numerous risks which are undertaken with each construction endeavor, such as legal risks, design risks, financial risks, political risks, etc. (Burr, 2018, p. 18).

In addition to fiscal risks which delays can cause, the purpose of the job being performed is also important to take into consideration. For example, the Kabul Military Training Center (KMTC) in Afghanistan was delayed over 4 years, partly due to "inadequate planning and oversight", however the contract files did not explain every reason for modification due to poor management (Trent, 2011, p. 6). The goal of the technical research is to be able to identify the specific reasoning behind delays. My team will be using historical data from three of Hourigan's past projects: Church Hill North Parcel B, Kinsale, and Town Center 4. Our objective is not only to determine the delays in solely these projects, but to research the topic on a larger scale; we plan to take into consideration different causations of delays which cannot be easily shown through a disrupted schedule. Examples of these include whether or not a certain subcontractor was repeatedly involved in the delays, what time of the year it was and whether or not the weather had an effect on the project, if there were issues acquiring work permits for the location, etc.

USING DELAY ANALYSIS TECHNIQUES FOR BETTER UNDERSTANDING

There are various Delay Analysis Techniques which can be implemented in order to understand the numerous effects of delays. In addition to performing a historical and statistical analysis of the data received from Hourigan, we will employ methods such as the Impacted As-Planned analysis. This method includes looking at how the planned schedule is affected by each

individual delay. Figure 2 depicts a visual representation of this analysis as shown through an example project schedule (Braimah, 2013, p. 512).

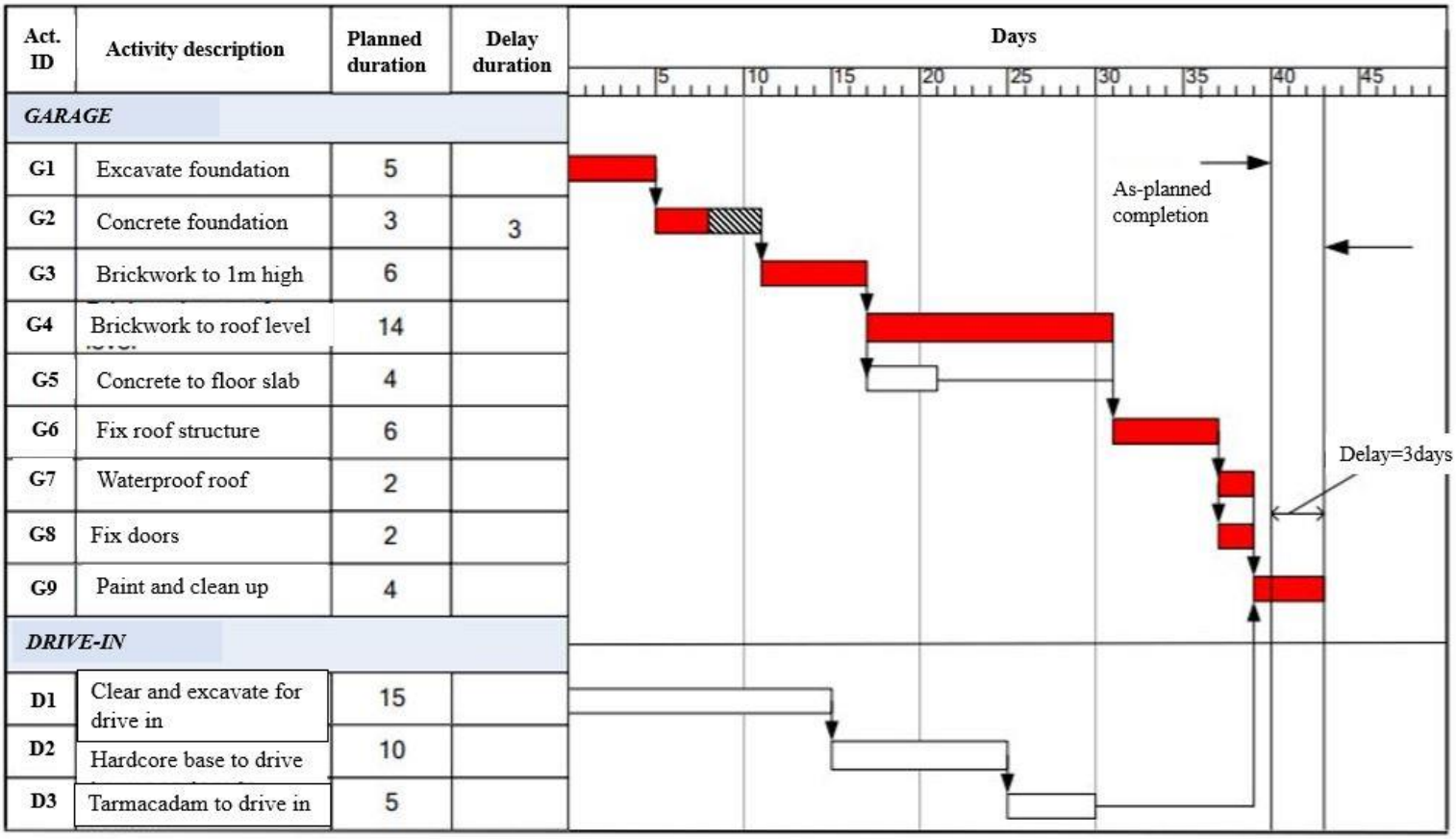

Figure 2: Impacted As-Planned Analysis. This figure shows the time impact of one specific delay, as shown through Activity G2, on the overall planned schedule. (Adapted by Zimmerman from N. Braimah, 2013).

From this visual, we are able to see that the 3-day delay from Activity G2 caused a delay of 3 days on the overall planned schedule. Using this method in the technical research will be helpful to identify the effects of specific delays throughout the project. Additionally, professors Baldwin and Bordoli (2014) note how the Window Analysis is the most widely accepted method of analysis, therefore this DAT will be performed in conjunction with the Impacted As-Planned method in order to ensure our research methods are comprehensive and valid (p. 327).

Through extensive exploration on the background of DATs together with conclusive research on the three case studies from Hourigan, my anticipated outcome is a guideline to present our sponsor which details how to adequately plan and schedule their future projects in order to decrease time and cost overruns in the future, while still ensuring the quality of the work done. My technical team will create general protocols to avoid these delays in the future, as well as provide a plan of action for how to combat them if they were to come up regardless of the measures previously taken. In addition to the deliverable we will give Hourigan, we will present our findings in a conference paper for the SIEDS Conference in April, 2021.

ROLE PLAYING OR PLAYING WITH ROLES? A CASE STUDY OF WOMEN IN THE WORKFORCE DURING WORLD WAR II

In the early 1940s, with World War II in full swing, many changes occurred among the available workforce. With the disappearance of available men to work due to their commitment to war efforts, jobs which previously discriminated against hiring women suddenly opened their doors to meet the needs of their production. Prominent figures like Rosie the Riveter emerged as the role of women was rapidly changing. In March 1941, 10.8 million women were employed, yet come August 1944, 18 million women were employed, including a 462% increase in growth of female employment in defense industries (Yesil, 2004, p. 105). Figure 3 on the next page shows three major sectors of work during WWII, and how women's participation in these industries changed throughout the war.

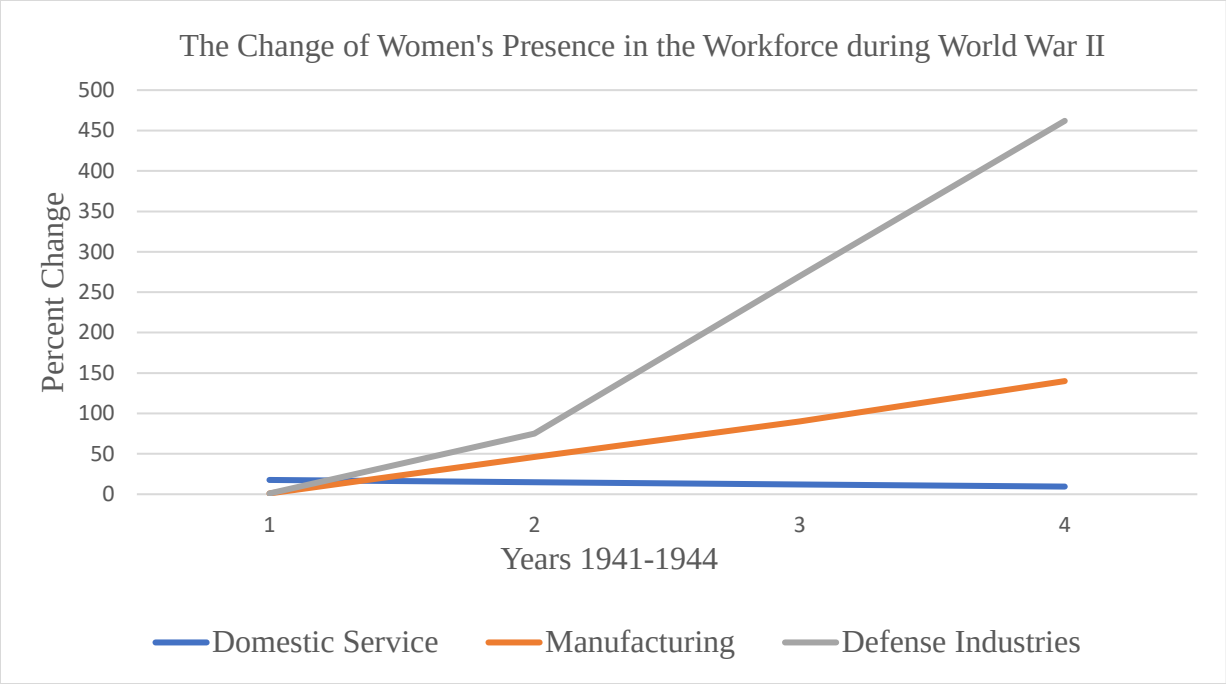

Figure 3: Women in the Workforce. This figure shows the percent change of women in the workforce in specific industries during World War II. (Created by A. Zimmerman from R. Milkman, 1982).

As seen from this figure, women's involvement decreased in domestic services, but significantly increased in the sectors of manufacturing and defense industries. These industries were able to adapt to this new set of workers, allowing for a "continuous improvement in production methods and in utilization of women workers throughout the war period" (Durr, Lide, West, & Freeman, 1991, p. 32). The increase in these fields makes logical sense due to the war efforts which were taking place during that time.

Although there was a large influx of women into the industries involving mechanical and industrial engineering, this fact does not imply that these women were widely accepted. Graduate professor Milkman (1982) made the point that although "Rosie the Riveter did a 'man's job'," such as within the auto industry, "…more often than not she worked in a predominantly female department or job classification" (p. 338). With this new demographic of workers, inequalities

within the workforce arose due to the basis of gender. In this regard, there is currently an insufficient amount of analytical research behind how these women were classified, and how their performance was measured in terms of quantitative performance metrics. For example, aside from industrial working positions, a large sector in need of women during this time was the medical industry. Author and historian Beaton (2020) noted how these women had to pass necessary evaluations in order to receive their positioning, such as being "a citizen of the United States or one of its Allies, a graduate of an approved nursing school, a registered nurse, and between the ages of twenty-one and forty… [and they] had to be single." However, when the war became more dire in "November 1942, army nurses, married or not, were recruited for the duration of the war plus six months and were forbidden to resign" (p. 31). Although it is known that women's roles were crucial to the war effort, more research needs to be conducted to determine their workplace metrics, and how we can compare those to similar climates today. The objective of the STS research is to understand the full depth of women's role in WWII and how their performance was evaluated as compared to males. Additionally, the treatment of women in these fields will be researched to determine how gender inequality affected these women both qualitatively, such as with through verbal/social treatment, and quantitatively, with measures such as the salary differences among genders for equivalent job positionings. As a result, this model can be used to understand the lack of presence of women in the construction/civil engineering industry today.

In order to have a better understanding of the role in which women played in WWII, and how their performance was therefore evaluated, the Actor Network Theory (ANT) will be used to research this model (Carlson, 2007). Figure 4 below shows the relationship between women in

the workforce as an actor in WWII and the other human actors, as well as some of the ideas/concepts which sprouted from these relationships.

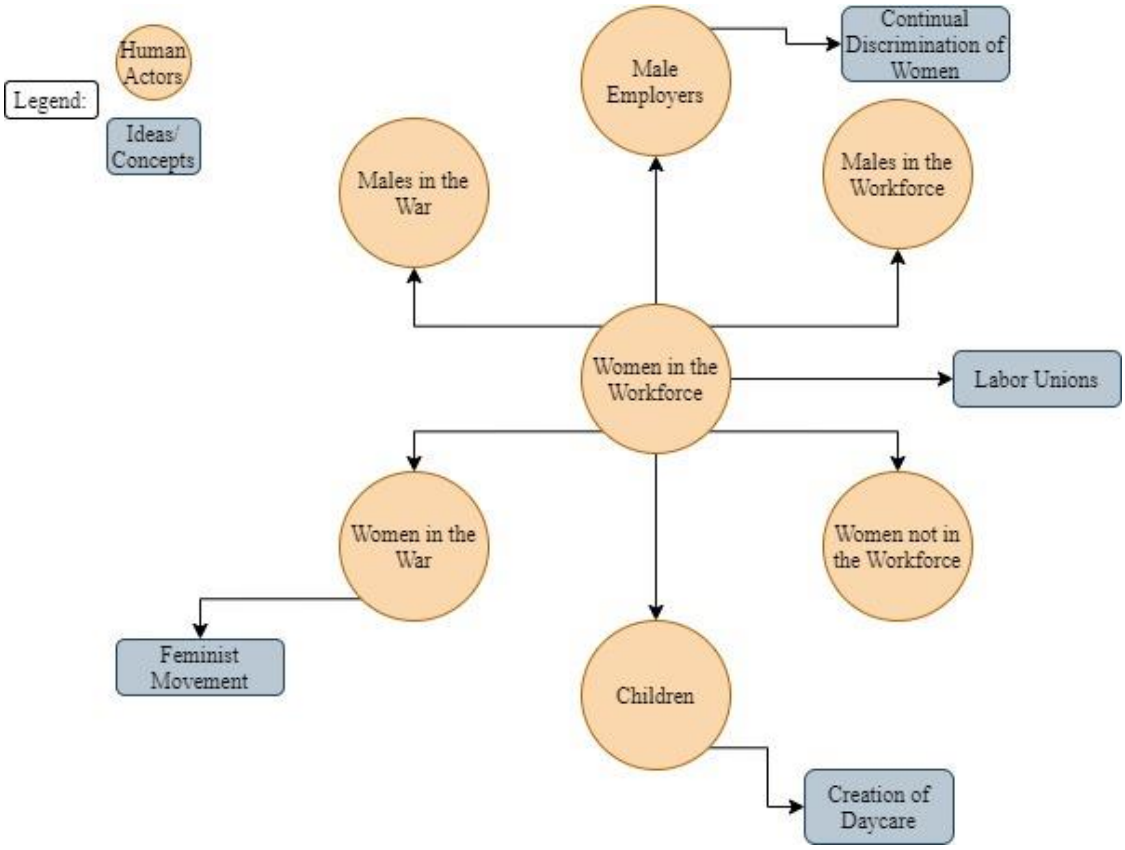

Figure 4: ANT of Women in WWII. This figure shows the different relationships present between women in the workforce during WWII with other human actors, as well as some of the concepts which were created from these relationships. (Created by A. Zimmerman, 2020).

By researching information by the flow of this chart, a better understanding can be reached of how these women were evaluated in the past, and therefore a valid comparison of how they are evaluated now can be created. Additionally, equality among genders can be further investigated by this network to determine the overall effect the difference in treatment had. Regardless of the conclusions this comparison may lead to, this research paper will be able to determine the cause for the lack of women in the field of construction/civil engineering, and discredit the discriminations which are imminently placed upon them.

IDENTIFYING DELAYS TO BETTER THE FUTURE

By identifying the root causes and responsible actors for delays within construction projects, jobs can be conducted in the future with less unforeseen costs and lost time, as well as a higher quality of work overall. Additionally, relationships within the workforce can be maintained by ensuring each individual is held accountable for their disruptions. The performance of these actors will be measured using the model of performance metrics during WWII. More specifically, the role of women in today's construction/civil engineering industry will be compared with the role of women in similar industries during WWII and the presence of gender inequality within this climate, both quantitatively and qualitatively. By comparing these two sets of workers, a better understanding can possibly be reached regarding the lack of women in the field today, and an explanation can therefore be provided to try and combat the deterrence of women from this line of work in the future.

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