Connecting Industry to Mathematics Instruction
NSF ATE Award # 1954291

Steel Consequences
Student Activity Sheet

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What is SteelFab?

SteelFab is a steel fabricator of structural steel. Steel ***fabrication*** is the process of turning raw steel material into forms and shapes according to contract drawings. The raw steel undergoes processes including but not limited to cutting, fitting, and welding to create structural frameworks for buildings.

Steel ***erection*** occurs when the frameworks are assembled. This process usually occurs in ***sequences***, meaning construction of the building frame is broken down into smaller, more manageable portions that are built in a specific order. First the individual ***pieces*** of steel in the sequence are fabricated at the plant then delivered to the worksite by the sequence or order in which it must be erected. Breaking down the construction of the building into sequences allows the worksite crew to ensure there is enough storage space and layout area for incoming steel.

Industry Terminology

- **Fabrication (Fab) Start** is the day that creation of a particular sequence begins.
- **Fab Duration** is the number of days needed to create a particular sequence.
- **Fab Finish** is the day that creation of a particular sequence is complete.
- **Erection Start** is the day that assembly of a particular sequence begins.
- **Erection Duration** is the number of days needed to assemble a particular sequence.
- **Erection Finish** is the day that assembly of a particular sequence is complete.

STEEL FABRICATION

STEEL ERECTION

SteelFab Activity

You are a project manager at SteelFab. You have been assigned to manage the framework construction of an office building in downtown Raleigh. The main objective of a project manager is to make sure your team's steel fabrication and erection is on time and cost effective. You will use the SteelFab:Steel Consequences Spreadsheet to manage the 4 phases of the construction project. Complete each Task in each Phase.

Phase 1: Complete the Steel Fabrication Table

The project drawing set has been approved for construction. The drawings indicate that the given numbers of sequences and pieces are needed to construct the framework of the building. As the project manager, you must determine the Fab Duration, Fab Start, and Fab Finish for each sequence.

KEY NOTES
• 8 fabricators work at a time to fabricate a sequence. • Each fabricator works 10 hours per day. • It takes 4 hours to fabricate 1 piece. • A Fab Start of "0" is the first day of the project.

[Task a] Create a formula to calculate the Fab Duration for each sequence. Write the relationship in words first. Enter the formula in E4 then fill the column to find the Fab Duration for each sequence. The Total Duration should be the sum for all of the sequences.

[Task b] Begin with a Fab Start of "0" for Seq. 1. Create a formula to calculate the Fab Start of the remaining sequences. Write the relationship in words first. Enter the formula in D5 then fill the column.

[Task c] Create a formula to calculate the Fab Finish of each sequence. Write the relationship in words first. Enter the formula in F4 then fill the column.

Phase 2: Initialize the Data

The graph provides a visual representation of the relationship between the fabrication and erection data. Now that your fabrication and erection tables are created, as project manager, you must predict the most efficient erection start day and finish day. In a perfect world there would be no delays, and the two tables would be your fabrication and erection timetable for the entire project.

KEY POINTS
● Begin with both start days set to "0". ● Only manipulate cells D4 (dark blue) and D16 (dark orange) unless noted otherwise. ● Assume 7 day work weeks.

[Task a] What information can you get from the graph?

[Task b] Can you identify any issues in the current graph of the data? If so, identify where they occur and why it's an issue.

[Task c] Assuming erection can begin once fabrication for a sequence is complete, what is the earliest day erection can start if Seq. 1 is completely fabricated?

[Task d] What does your answer to 2c above represent in the Erection table? Where would you enter this value in the Erection table? Enter the value. Explain what is happening in the new graph and what this tells us about what is happening at the jobsite.

Phase 3: Address Unforeseen Circumstances

In the real world, we know that problems at the fabrication plant or at the building site will likely occur. As project manager, you must determine how delays affect your timetable.

KEY POINTS
● Phase 3 begins where Phase 2 ends. ● Only manipulate cells D4 (dark blue) and D16 (dark orange) unless noted otherwise. ● Assume 7 day work weeks.

[Task a] Brainstorm a list of potential problems which could occur during the fabrication and erection processes that would affect the start and the finish days of the sequences and the overall project?

[Task b] The erector welders contracted food poisoning from a food truck. Construction stopped for 2 days because there were not enough available workers. All workers were able to return to work on the 3rd day. Based on the erection start day you found in Phase 2c-d, on what day will erection for Seq. 1 now be complete, taking the sick delay into consideration?

[Task c] Analyze the current graph. Is there still an issue? If so, play around with the value in the D16 (dark orange cell) until you find an erection start day that will allow approximately 5 days between Seq. 8 fabrication start and Seq. 8 erection start.

[Task d] Analyze how many sequences have been fabricated by the erection start day you found in Phase 3c above.

[Task e] You are allotted 60 days for fabrication and erection. Based on the current table, will you be able to complete the work in this time? How many days will you go over or have to spare? What are the potential economic impacts?

[Task f] A tropical storm floods the jobsite and delays the start of erection by 3 weeks. What is the new end day for all erection to be completed? By how many days over the allotted 60 days will erection run over?

Phase 4: Billing and Turnover

Depending on the size of the project, a project can take several months to construct. If the fabrication and erection times do not align correctly, SteelFab will lose money. Billing invoices are sent to clients after every 30 days of the project. Clients only pay for the completed portion of the project. As project manager, you must determine the billing amounts throughout construction.

KEY POINTS
● Phase 4 begins where Phase 3 ends. ● Only manipulate cells D4 (dark blue) and D16 (dark orange) unless noted otherwise. ● Assume 7 day work weeks.

[Task a] The current fabrication schedule is based on a 10-hour work day per worker. To make up for lost time after an equipment breakdown, we have agreed to pay 2 hours overtime per day for each worker to work 12-hour days. What is the total duration for fabrication now? Manipulate cell E4 then fill the column to find the Fab Duration for each sequence. The Total Duration should be the sum for all of the sequences.

[Task b] If the initial fabrication drawings were delayed by a week, what would be the new Fab Start day for Seq. 8? How could this change affect billing?

[Task c] Edit your tables to match the start days you had for Phase 3c, keeping the accelerated fabrication time. We can bill the client every 30 days. Approximately what percent of fabrication will be included in the first bill? What percent of erection can we bill for?
Note: Sequences must be completely fabricated and erected before we can bill for it.

[Task d] Fabrication welders are paid $60/hour. Calculate the amount SteelFab must pay them based on Phase 4c above.