CEE 538
Lab 6: THE WAREHOUSE PROJECT
Part 1: Resource-Restrained Scheduling

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Fall 2025 — Due: November 25, 2025

Description of the "Warehouse Project"

Study the Warehouse Project case study (attached) and the following article (included in the CEE536 course notes on Canvas):

> Fondahl, J. (1991). "The Development of the Construction Engineer: Past Progress and Future Problems" *J. Constr. Eng. Mgmt.*, ASCE, Vol 117, No 3, pp 380-392.

The Warehouse Project is used as an example in (Fondahl 1991) to illustrate the effects of limited resources on construction schedules. Several schedules for the Warehouse Project developed in *Primavera P3* and *Suretrak* (included in the CEE536 course notes) also illustrate the effects of limited resources on the schedule. (*P3* and *Suretrak* were scheduling software by *Primavera Systems* that were discontinued when the company was acquired by *Oracle.*)

Tasks for this assignment:

1. Schedule the Warehouse Project using MS Project and P6 and investigate the effects of limited resources on construction schedules, as described in (Fondahl 1991).
2. Explore the capabilities of MS Project and P6 to schedule projects with limited resources and compare them to older software (i.e., P3 and Suretrak).

Resource Definition

The Warehouse Project requires three "labor" resources to be defined in MS Project and P6: *Carpenters* (C), *Ironworkers* (I) and *Laborers* (L), as shown below:

Resource ID	Resource Name:	Max Units/Time:	Calendar:
C	Carpenters	4 units/day	7-Day Workweek
I	Ironworkers	4 units/day	7-Day Workweek
L	Laborers	4 units/day	7-Day Workweek

The "Default Units/Time" and "Price/Unit" do not matter for this assignment.

Part 1 — Warehouse Project Schedule before the Change Order

Schedule the Warehouse Project in MS Project and P6 to start on **Nov 1, 2025**. To make it easy to compare schedules, use the "7-Day Workweek" calendar for all activities and resources. Note that MS Project and P6 cannot split activities automatically when leveling resources.

Contrary to the statement in (Fondahl 1991), later versions of P3 could automatically split activities when leveling limited resources. This is shown in the P3 schedule titled "*Leveled by*

P3, with Splits: T=28 days" where P3 achieved a project duration of T=28d (shortest possible) by automatically splitting Activities 5 and 8 in two (5A & 5B and 8A & 8B) as follows:

Original Activity (duration)	Split by P3 into two activities		Work break (lag) between the two activities (due to resource leveling by P3)
Act 5 (4d)	**5A (1d)**	**5B (3d)**	Break between 5A and 5B = 2d
Act 8 (3d)	**8A (1d)**	**8B (2d)**	Break between 8A and 8B = 2d

Lab 6 Part 1 Report

A. Your report should start with a description of the Warehouse Project that makes it self-contained so that someone not in CEE536 or CEE538 can read it and understand it.

B. The "Critical Path" was originally defined as the *longest* path of successive activities that spans a project network from start to finish and thus determines the shortest possible duration for the project. The activities on the "Critical Path" were called "*Critical Activities*".
Given your observations from scheduling projects with *limited resources*, answer the following questions:

1. Under what conditions does a schedule network have a "*Critical Path*", i.e., *a "Longest Path"*? When does a project not have a "*Critical Path*"?
2. What is the best way to define "*Critical Activities*"?

C. Your description should also compare the various MS Project and P6 schedules (that follow) to each other and to those by P3.

D. Develop and include four MS Project reports and three P6 reports like those attached.

- Early-Start Schedule – Unleveled: T=28d
- Leveled without splitting activities: T=31d (MS-Project), T=29d (P6)
- Leveled with activities split in two as by P3 above (do not model the break): T=28d

ZIP file (sent through email to photios@umich.edu)

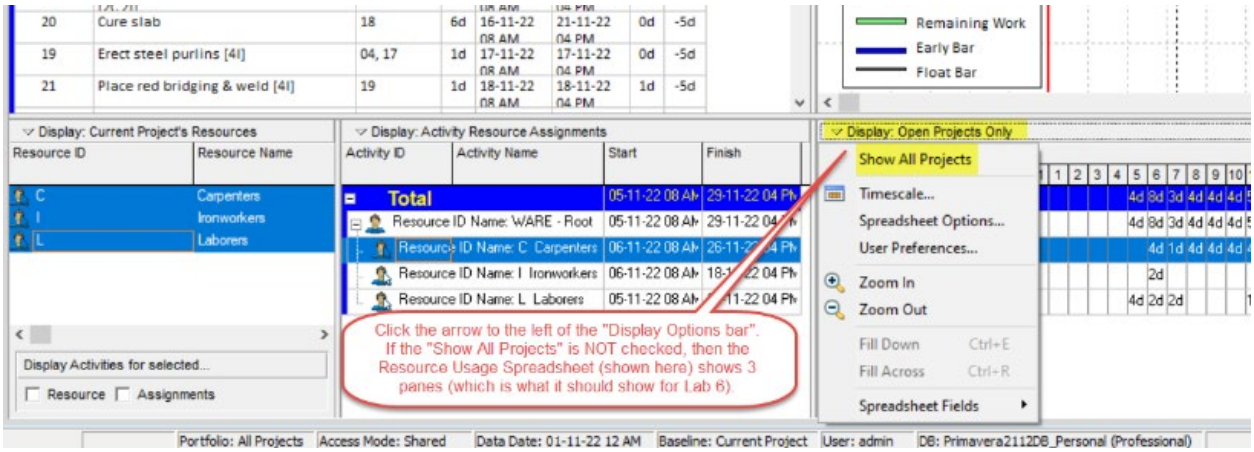
Zip the files for your work for Lab 6-1 in a file named "Lab6-1-Lastname_FirstName.zip' and email it as an attachment to photios@umich.edu.

The zip file "Lab6-1-Lastname_FirstName.zip" should contain 5 files:

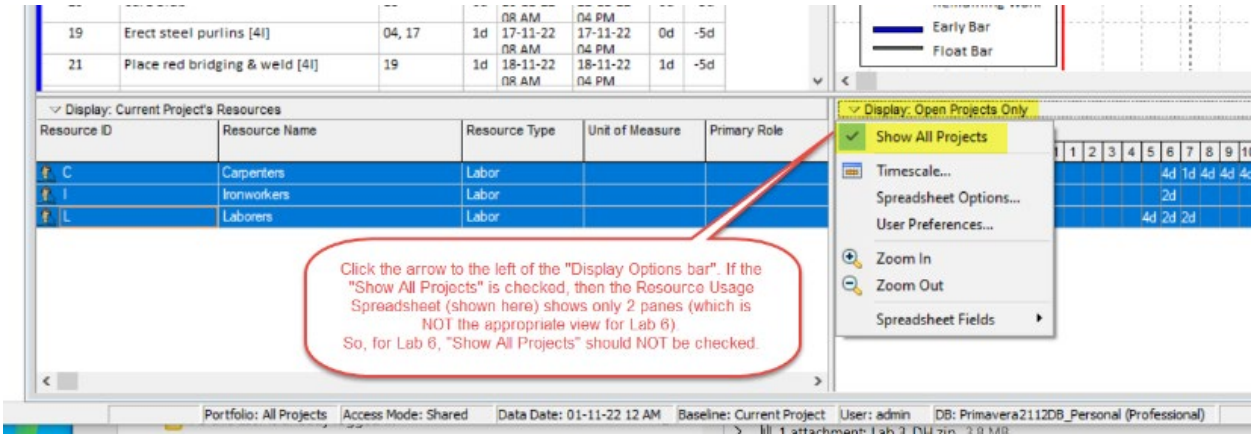
- Lab6-1-Report-Lastname_FirstName.pdf
  - This is the PDF file for your report.
- Lab6-1-Lastname_FirstName_x.mpp (3 files)
  - These are your MS Project files for x=1,2,3.
- Lab6-1-Lastname_FirstName-PrimaveraDB_Personal.db
  - This is your SQLite database file created by P6 Pro. Both the username and password must be "admin".

Notes for P6 — How to show three panes for the "Resource Usage Spreadsheet"

The view for the Resource Usage Spreadsheet in P6 for Lab 6 should show 3 panes, left-middle-right, as shown in screenshot below.



Sometimes, however, the P6 "Resource Usage Spreadsheet" shows only 2 panes (as shown in the second screenshot below):



To show three panes in the P6 "Resource Usage Spreadsheet" (instead of only two panes):

- Click on the arrow to the left of the "Display Options bar" (which is the bar on the top row above the spreadsheet cells that appear on the right pane of the "Resource Usage Spreadsheet)" and make sure that the option "Show All Projects" is <u>not</u> checked.

When the option "Show All Projects" is not checked, the P6 "Resource Usage Spreadsheet" should show 3 panes (which is the appropriate view).

If P6 still shows only two panes (i.e., the middle pane and the right pane), then the left pane is currently hidden behind the middle pane. In this case, click the left border of the middle pane (notice that the left border is actually two borders next to each other) and drag it to the right to reveal the left pane which is currently hidden behind the middle pane.

CASE STUDY: THE WAREHOUSE PROJECT[1]

You are the successful contractor for a warehouse project. Based on the original bidding documents, you have developed the activity list shown in Table 1 which includes the activity number, the activity name, the activity duration, the set of predecessor activities, and the daily resource requirements.

The contract for this project requires completion within 28 working days after the *Notice to Proceed* and calls for liquidated damages for late completion at the rate of $1,000 per working day. The *General Conditions* of the contract include a clause identical to *SP-13* of the *U.S. Postal Service Specifications* (shown below). Following contract award, you submitted a computer printout of your master schedule that shows completion of the work in 28 working days.

At the time of the notice to proceed, the owner issues a *Change Order* and informs you that he has redesigned some of the work. This increases the duration of Activities 3, 7, 8, and 29 as follows:

Activity	Original Duration	New Duration	Duration Increase	Free Float (for comparison)
03-Fabricate interior wall partition [4C]	2d	8d	6d	15d
07-Fabricate exterior doors [2C]	2d	7d	5d	17d
08-Const. plywood ext. wall panel [4C]	3d	12d	9d	14d
29-Erect interior wall partitions [4C]	1d	4d	3d	4d

The owner agrees to pay the additional costs caused by the *Change Order* but refuses to allow any time extension. At this point, you become concerned about possible resource availability. **Each day you can only provide 4 carpenters (C), 4 ironworkers (I), and 4 laborers (L).**

Part 1

- Develop a schedule showing that you could complete the original project (before the *Change Order*) within 28 days without exceeding your resource availability constraints.
- Why do you think the owner denied granting the revised project any time extension?

Part 2

You now realize that you can no longer meet the 28-day schedule under the *Change Order* requirements. Thus, you accept the *Change Order* under protest, indicating that you do not agree with the owner's denial of time extension.

- How much time extension should you claim? Document your claim by producing a schedule using the revised activity duration estimates and subject to the above resource availability constraints. Knowing that this schedule will be challenged by the owner's top engineering talent, you must develop the shortest schedule possible.
- How much time extension should you claim if you could split activities?

Example 1: *General Services Administration* (GSA) Specification

"Adjustment of Contract Completion Time

The contractor acknowledges and agrees that actual delays in activities which, according to the computer-produced calendar-dated schedule, do not affect any contract completion date shown by the critical path in the network, do not have any effect on the contract completion date or dates and therefore will not be the basis for a change therein."

[1] Adapted by P.G. Ioannou from
"*Seabee Planner's and Estimator's Handbook*"
NavDocks-P-405, Dept. of the Navy, Bureau of Yards and Docks, Washington DC, circa 1960.

Example 2: *U.S. Postal Service* (USPS) Specification

"SP-13 Contractor-Prepared Network Analysis System* (NAS)*:

Float or slack is defined as the amount of time between the early start date, and the late start date, or the early finish date and the late finish date of any of the activities in the NAS schedule. Float or slack is not time for the exclusive use or benefit of either the Government or the Contractor. Extensions of time for performance required under the Contract General provisions entitled, "CHANGES", "DIFFERING SITE CONDITIONS", "TERMINATION FOR DEFAULT", "DAMAGES FOR DELAY", "TIME EXTENSIONS", OR "SUSPENSION OF WORK" will be granted only to the extent that equitable time adjustments for the activity or activities affected exceed the total float or slack along the channels involved."

TABLE 1. Activity List for Warehouse Project

MSP ID	P6 ID	Activity Name	Dur (d)	Predecessors	Resources
1	01	01-Site survey & material list	1		-
2	02	02-Material & equipment to site	3	1	-
3	03	03-Fabricate interior wall partition [4C]	2	2	4C
4	04	04-Fasten wood strips to purlins [2C]	2	2	2C
5	05	05-Fabricate timber trusses [4C]	4	2	4C
6	06	06-Excavate [4L]	1	2	4L
7	07	07-Fabricate exterior doors [2C]	2	2	2C
8	08	08-Const. plywood ext. wall panel [4C]	3	2	4C
9	09	09-Forms, rebar & bolts for col ftgs [4C,2I,2L]	1	6	4C, 2I, 2L
10	10	10-Place drain pipes [SUB]	1	6	SUB
11	11	11-Pour footings [1C,2L]	1	9	1C, 2L
12	12	12-Strip footings [1L]	1	11	1L
13	13	13-Erect steel cols & vert brace [4I]	1	12	4I
14	14	14-Backfill, compact & grade slab [2L]	2	10,12	2L
15	15	15-Erect trusses [4I]	1	13,5	4I
16	16	16-Forms, rebar & drains floor slab [4C,2I]	1	14	4C, 2I
17	17	17-Fab & erect frames @ truss pans [2C,2I]	1	15	2C, 2I
18	18	18-Pour slab [1C,2L]	1	13,16	1C, 2L
19	19	19-Erect steel purlins [4I]	1	4,17	4I
20	20	20-Cure slab	6	18	-
21	21	21-Place red bridging & weld [4I]	1	19	4I
22	22	22-Erect ext. wall panels [4C]	2	20,8	4C
23	23	23-Nail planks to purlins [2C]	2	21	2C
24	24	24-Erect doors [2C]	1	7,22	2C
25	25	25-Waterproof & insulate joints [2L]	1	22	2L
26	26	26-Lay tar paper on planks [2L]	1	23	2L
27	27	27-Paint ext. walls [SUB]	2	24,25	SUB
28	28	28-Erect corrugated roofing [2C]	2	26	2C
29	29	29-Erect interior wall partitions [4C]	1	3,20,26	4C
30	30	30-Cleanup [4L]	2	27,28,29	4L

MSP ID: Activity ID numbers to use in MS Project Pro (consecutive numbers).
P6 ID: Activity ID numbers to use in P6 Pro (similar to the numbers used by Fondahl, P3, and Suretrak).

IMPORTANT: The link between Activities "11-Pour footings" and "12-Strip footings" should be Finish-to-Start with a Lead Time, LT=3 days, to represent the required 3 days of concrete curing time for the footings.

TABLE 2. Resource Leveling Effects on Criticality–Warehouse Project[1]

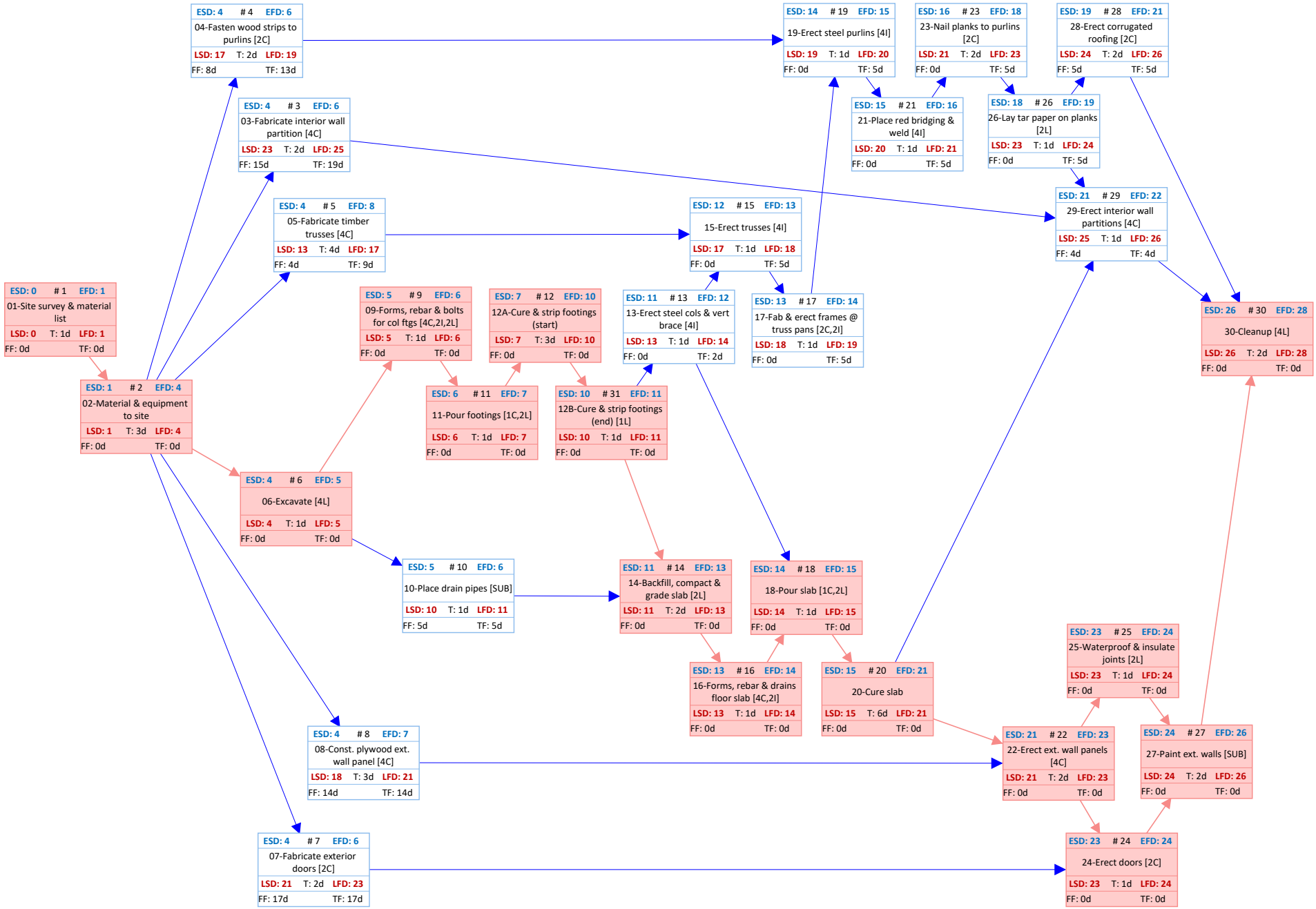
MSP Act ID (1)	P6 Act ID (1)	Total float before leveling (2)	Original critical (3)	Total float used in rescheduling (4)	Theoretical remaining total float (5)	Actual remaining total float (6)	Critical after leveling (7)
1	1	0	C	-	-	-	C
2	2	0	C	-	-	-	C
3	3	19	-	15	4	0	C
4	4	13	-	2	11	0	C
5 (1d)	5A (1d)	9	-	0	9	0	C
32 (3d)	5B (3d)	9	-	3	6	0	C
6	6	0	C	-	-	-	C
7	7	17	-	12	5	1	-
8 (1d)	8A (1d)	14	-	7	7	0	C
33 (2d)	8B (2d)	14	-	9	5	1	-
9	9	0	C	-	-	-	C
10	10	5	-	0	5	5	-
11	11	0	C	-	-	-	C
12	12	0	C	-	-	-	C
13	13	2	-	0	2	0	C
14	14	0	C	-	-	-	C
15	15	5	-	0	5	0	C
16	16	0	C	-	-	-	C
17	17	5	-	1	4	0	C
18	18	0	C	-	-	-	C
19	19	5	-	1	4	0	C
20	20	0	C	-	-	-	C
21	21	5	-	1	4	0	C
22	22	0	C	-	-	-	C
23	23	5	-	1	4	0	C
24	24	0	C	-	-	-	C
25	25	0	C	-	-	-	C
26	26	5	-	1	4	3	-
27	27	0	C	-	-	-	C
28	28	5	-	4	1	0	C
29	29	4	-	4	0	0	C
30	30	0	C	-	-	-	C

[1] Table 2 is a revised version of Table 1 from the paper:
Fondahl, J. (1991). "*The Development of the Construction Engineer: Past Progress and Future Problems*" J. Constr. Eng. Mgmt., ASCE, Vol 117, No 3, pp 380-392.

Main changes: In Table 2, each of the three activities 5, 8, and 12 has been split into two activities as follows:

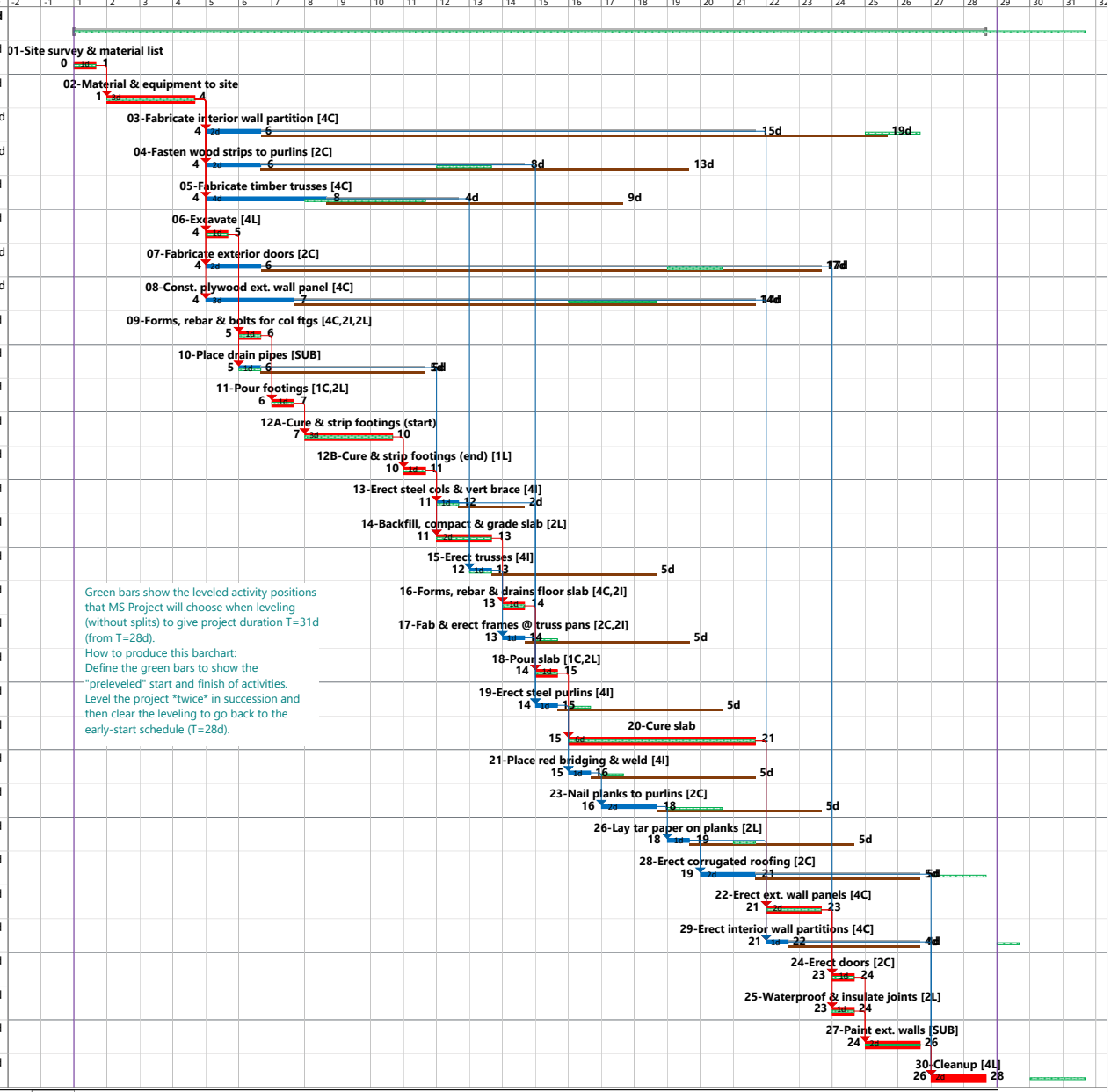
Original Activity (Dur)		**Split MS Project Activities** (Dur)	**Split P6 Activities** (Dur)
5 (4d)	=	**5** (1d) + **32** (3d)	**5A** (1d) + **5B** (3d)
8 (3d)	=	**8** (1d) + **33** (2d)	**8A** (1d) + **8B** (2d)

This enables MS Project and P6 (neither of which can split activities automatically when leveling resources) to "split" into two activities each of the two activities 5 and 8, as described by Fondahl (1991).


ESD: 0 # 1 EFD: 1
01-Site survey & material list
LSD: 0 T: 1d LFD: 1
FF: 0d TF: 0d
ESD: 1 # 2 EFD: 4
02-Material & equipment to site
LSD: 1 T: 3d LFD: 4
FF: 0d TF: 0d
ESD: 4 # 4 EFD: 6
04-Fasten wood strips to purlins [2C]
LSD: 17 T: 2d LFD: 19
FF: 8d TF: 13d
ESD: 4 # 3 EFD: 6
03-Fabricate interior wall partition [4C]
LSD: 23 T: 2d LFD: 25
FF: 15d TF: 19d
ESD: 4 # 5 EFD: 8
05-Fabricate timber trusses [4C]
LSD: 13 T: 4d LFD: 17
FF: 4d TF: 9d
ESD: 5 # 9 EFD: 6
09-Forms, rebar & bolts for col ftgs [4C,2I,2L]
LSD: 5 T: 1d LFD: 6
FF: 0d TF: 0d
ESD: 7 # 12 EFD: 10
12A-Cure & strip footings (start)
LSD: 7 T: 3d LFD: 10
FF: 0d TF: 0d
ESD: 6 # 11 EFD: 7
11-Pour footings [1C,2L]
LSD: 6 T: 1d LFD: 7
FF: 0d TF: 0d
ESD: 10 # 31 EFD: 11
12B-Cure & strip footings (end) [1L]
LSD: 10 T: 1d LFD: 11
FF: 0d TF: 0d
ESD: 11 # 13 EFD: 12
13-Erect steel cols & vert brace [4I]
LSD: 13 T: 1d LFD: 14
FF: 0d TF: 2d
ESD: 12 # 15 EFD: 13
15-Erect trusses [4I]
LSD: 17 T: 1d LFD: 18
FF: 0d TF: 5d
ESD: 13 # 17 EFD: 14
17-Fab & erect frames @ truss pans [2C,2I]
LSD: 18 T: 1d LFD: 19
FF: 0d TF: 5d
ESD: 14 # 19 EFD: 15
19-Erect steel purlins [4I]
LSD: 19 T: 1d LFD: 20
FF: 0d TF: 5d
ESD: 15 # 21 EFD: 16
21-Place red bridging & weld [4I]
LSD: 20 T: 1d LFD: 21
FF: 0d TF: 5d
ESD: 16 # 23 EFD: 18
23-Nail planks to purlins [2C]
LSD: 21 T: 2d LFD: 23
FF: 0d TF: 5d
ESD: 18 # 26 EFD: 19
26-Lay tar paper on planks [2L]
LSD: 23 T: 1d LFD: 24
FF: 0d TF: 5d
ESD: 19 # 28 EFD: 21
28-Erect corrugated roofing [2C]
LSD: 24 T: 2d LFD: 26
FF: 5d TF: 5d
ESD: 21 # 29 EFD: 22
29-Erect interior wall partitions [4C]
LSD: 25 T: 1d LFD: 26
FF: 4d TF: 4d
ESD: 26 # 30 EFD: 28
30-Cleanup [4L]
LSD: 26 T: 2d LFD: 28
FF: 0d TF: 0d
ESD: 4 # 6 EFD: 5
06-Excavate [4L]
LSD: 4 T: 1d LFD: 5
FF: 0d TF: 0d
ESD: 5 # 10 EFD: 6
10-Place drain pipes [SUB]
LSD: 10 T: 1d LFD: 11
FF: 5d TF: 5d
ESD: 11 # 14 EFD: 13
14-Backfill, compact & grade slab [2L]
LSD: 11 T: 2d LFD: 13
FF: 0d TF: 0d
ESD: 14 # 18 EFD: 15
18-Pour slab [1C,2L]
LSD: 14 T: 1d LFD: 15
FF: 0d TF: 0d
ESD: 13 # 16 EFD: 14
16-Forms, rebar & drains floor slab [4C,2I]
LSD: 13 T: 1d LFD: 14
FF: 0d TF: 0d
ESD: 15 # 20 EFD: 21
20-Cure slab
LSD: 15 T: 6d LFD: 21
FF: 0d TF: 0d
ESD: 4 # 8 EFD: 7
08-Const. plywood ext. wall panel [4C]
LSD: 18 T: 3d LFD: 21
FF: 14d TF: 14d
ESD: 4 # 7 EFD: 6
07-Fabricate exterior doors [2C]
LSD: 21 T: 2d LFD: 23
FF: 17d TF: 17d
ESD: 23 # 25 EFD: 24
25-Waterproof & insulate joints [2L]
LSD: 23 T: 1d LFD: 24
FF: 0d TF: 0d
ESD: 21 # 22 EFD: 23
22-Erect ext. wall panels [4C]
LSD: 21 T: 2d LFD: 23
FF: 0d TF: 0d
ESD: 24 # 27 EFD: 26
27-Paint ext. walls [SUB]
LSD: 24 T: 2d LFD: 26
FF: 0d TF: 0d
ESD: 23 # 24 EFD: 24
24-Erect doors [2C]
LSD: 23 T: 1d LFD: 24
FF: 0d TF: 0d

MS Project Pro | Project: Warehouse Project | Date: 7/25/25

ID	Act	Pred	T	Lev	ESD	PSD	LSD	EFD	PFD	LFD	FF	TF
0	**Warehouse Project**		**28d**	**0ed**	**0**	**0**	**0**	**0**	**0**	**0**	**0d**	**0d**
1	01-Site survey & material list		1d	0ed	0	0	0	1	1	1	0d	0d
2	02-Material & equipment to site	1	3d	0ed	1	1	1	4	4	4	0d	0d
3	03-Fabricate interior wall partition [4C]	2	2d	0ed	4	24	23	6	26	25	15d	19d
4	04-Fasten wood strips to purlins [2C]	2	2d	0ed	4	11	17	6	13	19	8d	13d
5	05-Fabricate timber trusses [4C]	2	4d	0ed	4	7	13	8	11	17	4d	9d
6	06-Excavate [4L]	2	1d	0ed	4	4	4	5	5	5	0d	0d
7	07-Fabricate exterior doors [2C]	2	2d	0ed	4	18	21	6	20	23	17d	17d
8	08-Const. plywood ext. wall panel [4C]	2	3d	0ed	4	15	18	7	18	21	14d	14d
9	09-Forms, rebar & bolts for col ftgs [4C,2I,2L]	6	1d	0ed	5	5	5	6	6	6	0d	0d
10	10-Place drain pipes [SUB]	6	1d	0ed	5	5	10	6	6	11	5d	5d
11	11-Pour footings [1C,2L]	9	1d	0ed	6	6	6	7	7	7	0d	0d
12	12A-Cure & strip footings (start)	11	3d	0ed	7	7	7	10	10	10	0d	0d
31	12B-Cure & strip footings (end) [1L]	12	1d	0ed	10	10	10	11	11	11	0d	0d
13	13-Erect steel cols & vert brace [4I]	31	1d	0ed	11	11	13	12	12	14	0d	2d
14	14-Backfill, compact & grade slab [2L]	10,31	2d	0ed	11	11	11	13	13	13	0d	0d
15	15-Erect trusses [4I]	13,5	1d	0ed	12	12	17	13	13	18	0d	5d
16	16-Forms, rebar & drains floor slab [4C,2I]	14	1d	0ed	13	13	13	14	14	14	0d	0d
17	17-Fab & erect frames @ truss pans [2C,2I]	15	1d	0ed	13	14	18	14	15	19	0d	5d
18	18-Pour slab [1C,2L]	13,16	1d	0ed	14	14	14	15	15	15	0d	0d
19	19-Erect steel purlins [4I]	4,17	1d	0ed	14	15	19	15	16	20	0d	5d
20	20-Cure slab	18	6d	0ed	15	15	15	21	21	21	0d	0d
21	21-Place red bridging & weld [4I]	19	1d	0ed	15	16	20	16	17	21	0d	5d
23	23-Nail planks to purlins [2C]	21	2d	0ed	16	18	21	18	20	23	0d	5d
26	26-Lay tar paper on planks [2L]	23	1d	0ed	18	20	23	19	21	24	0d	5d
28	28-Erect corrugated roofing [2C]	26	2d	0ed	19	26	24	21	28	26	5d	5d
22	22-Erect ext. wall panels [4C]	20,8	2d	0ed	21	21	21	23	23	23	0d	0d
29	29-Erect interior wall partitions [4C]	3,20,26	1d	0ed	21	28	25	22	29	26	4d	4d
24	24-Erect doors [2C]	7,22	1d	0ed	23	23	23	24	24	24	0d	0d
25	25-Waterproof & insulate joints [2L]	22	1d	0ed	23	23	23	24	24	24	0d	0d
27	27-Paint ext. walls [SUB]	24,25	2d	0ed	24	24	24	26	26	26	0d	0d
30	30-Cleanup [4L]	27,28,29	2d	0ed	26	29	26	28	31	28	0d	0d



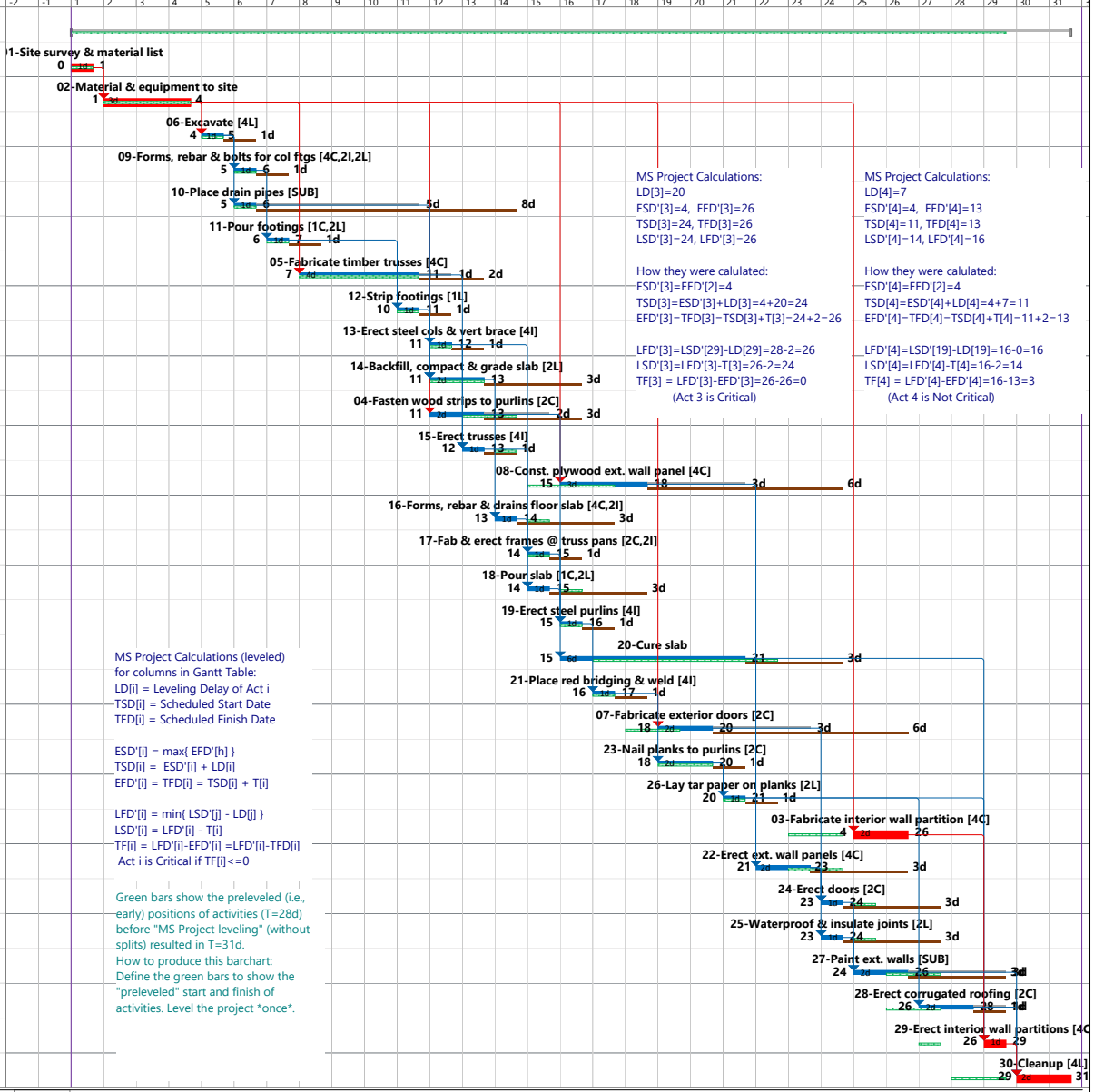
Green bars show the leveled activity positions that MS Project will choose when leveling (without splits) to give project duration T=31d (from T=28d).
How to produce this barchart:
Define the green bars to show the "preleveled" start and finish of activities.
Level the project *twice* in succession and then clear the leveling to go back to the early-start schedule (T=28d).

ID	Resource Name	Work	Details
	Unassigned	0d	Work
1	Carpenters	78d	Work
3	Laborers	27d	Work
2	Ironworkers	22d	Work

Note: The Resource Usage spreadsheet, shown on the right, was printed to pdf separately and was pasted to the pdf for the Gantt Chart using "Bluebeam Revu". If you find this too difficult, you can print and submit the two reports separately.

MS Project Pro | Project: Warehouse Project | Date: 7/25/25

ID	Act	Pred	T	Lev	PSD	ESD	TSD	LSD	PFD	EFD	TFD	LFD	FF	TF
0	**Warehouse Project**		**31d**	**0ed**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0d**	**0d**
1	01-Site survey & material list		1d	0ed	0	0	0	0	1	1	1	1	0d	0d
2	02-Material & equipment to site	1	3d	0ed	1	1	1	1	4	4	4	4	0d	0d
6	06-Excavate [4L]	2	1d	0ed	4	4	4	5	5	5	5	6	0d	1d
9	09-Forms, rebar & bolts for col ftgs [4C,2I,2L]	6	1d	0ed	5	5	5	6	6	6	6	7	0d	1d
10	10-Place drain pipes [SUB]	6	1d	0ed	5	5	5	13	6	6	6	14	5d	8d
11	11-Pour footings [1C,2L]	9	1d	0ed	6	6	6	7	7	7	7	8	0d	1d
5	05-Fabricate timber trusses [4C]	2	4d	3ed	7	4	7	9	11	11	11	13	1d	2d
12	12-Strip footings [1L]	11FS+3d	1d	0ed	10	10	10	11	11	11	11	12	0d	1d
13	13-Erect steel cols & vert brace [4I]	12	1d	0ed	11	11	11	12	12	12	12	13	0d	1d
14	14-Backfill, compact & grade slab [2L]	10,12	2d	0ed	11	11	11	14	13	13	13	16	0d	3d
4	04-Fasten wood strips to purlins [2C]	2	2d	7ed	12	4	11	14	14	13	13	16	2d	3d
15	15-Erect trusses [4I]	13,5	1d	0ed	13	12	12	13	14	13	13	14	0d	1d
8	08-Const. plywood ext. wall panel [4C]	2	3d	11ed	14	4	15	21	17	18	18	24	3d	6d
16	16-Forms, rebar & drains floor slab [4C,2I]	14	1d	0ed	14	13	13	16	15	14	14	17	0d	3d
17	17-Fab & erect frames @ truss pans [2C,2I]	15	1d	1ed	14	13	14	15	15	15	15	16	0d	1d
18	18-Pour slab [1C,2L]	13,16	1d	0ed	15	14	14	17	16	15	15	18	0d	3d
19	19-Erect steel purlins [4I]	4,17	1d	0ed	15	15	15	16	16	16	16	17	0d	1d
20	20-Cure slab	18	6d	0ed	16	15	15	18	22	21	21	24	0d	3d
21	21-Place red bridging & weld [4I]	19	1d	0ed	16	16	16	17	17	17	17	18	0d	1d
7	07-Fabricate exterior doors [2C]	2	2d	14ed	17	4	18	24	19	20	20	26	3d	6d
22	23-Nail planks to purlins [2C]	21	2d	1ed	18	17	18	19	20	20	20	21	0d	1d
23	26-Lay tar paper on planks [2L]	22	1d	0ed	20	20	20	21	21	21	21	22	0d	1d
3	03-Fabricate interior wall partition [4C]	2	2d	20ed	22	4	24	24	24	26	26	26	0d	0d
25	22-Erect ext. wall panels [4C]	20,8	2d	0ed	22	21	21	24	24	23	23	26	0d	3d
27	24-Erect doors [2C]	7,25	1d	0ed	24	23	23	26	25	24	24	27	0d	3d
28	25-Waterproof & insulate joints [2L]	25	1d	0ed	24	23	23	26	25	24	24	27	0d	3d
29	27-Paint ext. walls [SUB]	27,28	2d	0ed	25	24	24	27	27	26	26	29	3d	3d
24	28-Erect corrugated roofing [2C]	23	2d	5ed	25	21	26	27	27	28	28	29	1d	1d
26	29-Erect interior wall partitions [4C]	3,20,23	1d	2ed	26	26	28	28	27	29	29	29	0d	0d
30	30-Cleanup [4L]	29,24,26	2d	0ed	27	29	29	29	29	31	31	31	0d	0d



MS Project Calculations:
LD[3]=20
ESD'[3]=4, EFD'[3]=26
TSD[3]=24, TFD[3]=26
LSD'[3]=24, LFD'[3]=26

How they were calulated:
ESD'[3]=EFD'[2]=4
TSD[3]=ESD'[3]+LD[3]=4+20=24
EFD'[3]=TFD[3]=TSD[3]+T[3]=24+2=26

LFD'[3]=LSD'[29]-LD[29]=28-2=26
LSD'[3]=LFD'[3]-T[3]=26-2=24
TF[3] = LFD'[3]-EFD'[3]=26-26=0
(Act 3 is Critical)

MS Project Calculations:
LD[4]=7
ESD'[4]=4, EFD'[4]=13
TSD[4]=11, TFD[4]=13
LSD'[4]=14, LFD'[4]=16

How they were calulated:
ESD'[4]=EFD'[2]=4
TSD[4]=ESD'[4]+LD[4]=4+7=11
EFD'[4]=TFD[4]=TSD[4]+T[4]=11+2=13

LFD'[4]=LSD'[19]-LD[19]=16-0=16
LSD'[4]=LFD'[4]-T[4]=16-2=14
TF[4] = LFD'[4]-EFD'[4]=16-13=3
(Act 4 is Not Critical)

MS Project Calculations (leveled) for columns in Gantt Table:
LD[i] = Leveling Delay of Act i
TSD[i] = Scheduled Start Date
TFD[i] = Scheduled Finish Date

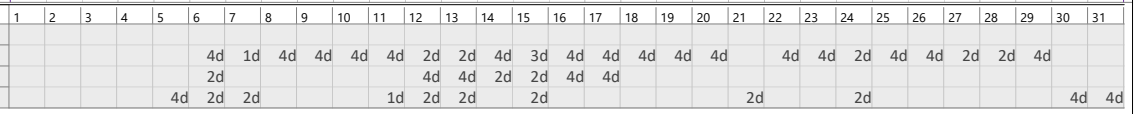
ESD'[i] = max{ EFD'[h] }
TSD[i] = ESD'[i] + LD[i]
EFD'[i] = TFD[i] + TSD[i] + T[i]

LFD'[i] = min{ LSD'[j] - LD[j] }
LSD'[i] = LFD'[i] - T[i]
TF[i] = LFD'[i]-EFD'[i] =LFD'[i]-TFD[i]
Act i is Critical if TF[i]<=0

Green bars show the preleveled (i.e., early) positions of activities (T=28d) before "MS Project leveling" (without splits) resulted in T=31d.
How to produce this barchart: Define the green bars to show the "preleveled" start and finish of activities. Level the project *once*.

Note: The Resource Usage spreadsheet, shown on the right, was printed to pdf separately and was pasted to the pdf for the Gantt Chart using "Bluebeam Revu".
If you find this too difficult, you can print and submit the two reports separately.

ID	Resource Name	Work	Details
	Unassigned	0d	Work
1	Carpenters	78d	Work
2	Ironworkers	22d	Work
3	Laborers	27d	Work



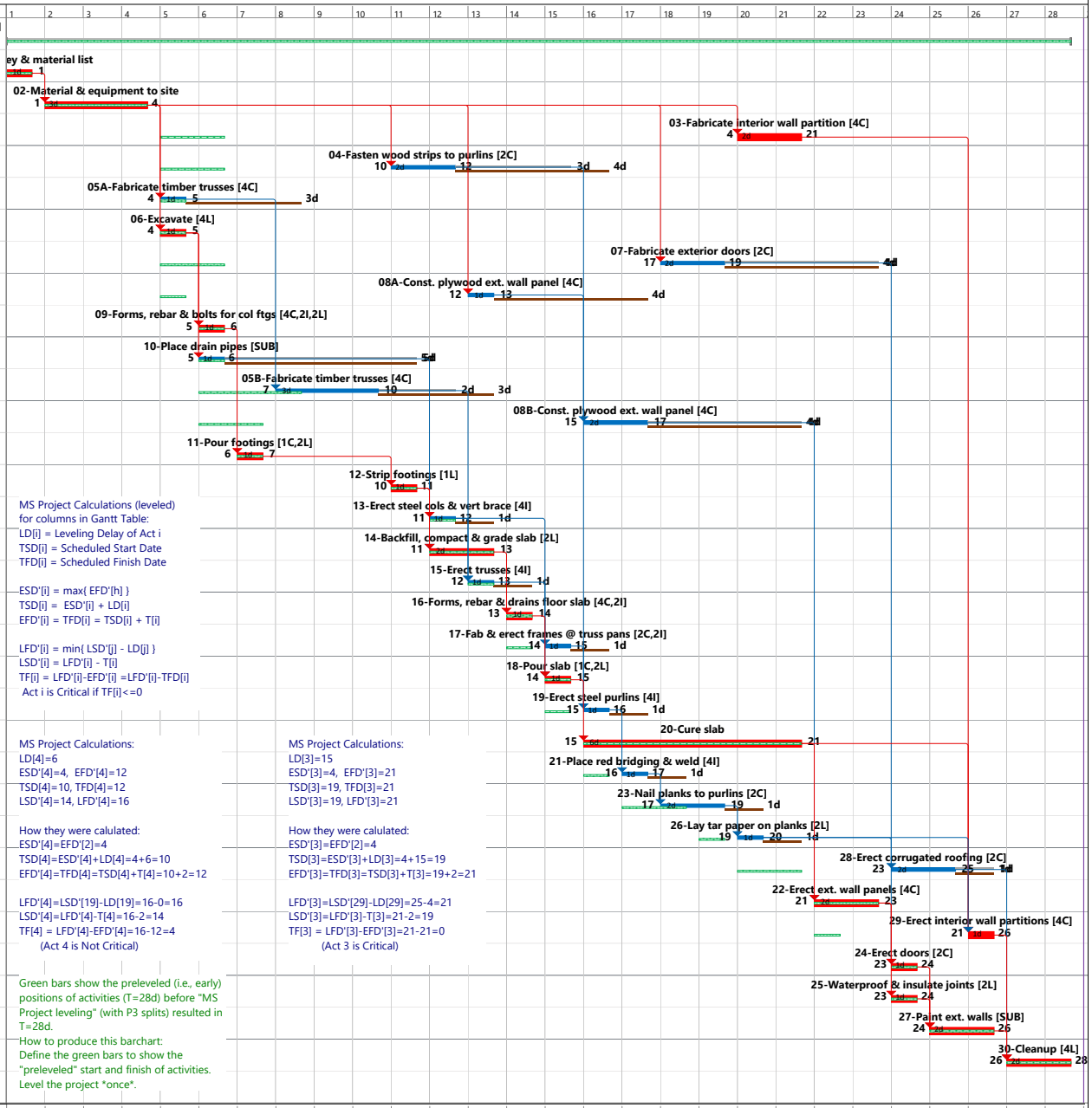
_Lab6.2_Gantt_Chart_No_Splits-T=31
Sorted by: Preleved Start, Name

Leveled by MS Project without splitting activities - Project duration T=31d (same as P3)

Course: CEE538
User: P.G. Ioannou

MS Project Pro | Project: Warehouse Project | Date: 7/25/25

ID	Act	Pred	T	Lev	PSD	ESD	TSD	LSD	PFD	EFD	TFD	LFD	FF	TF
0	**Warehouse Project**		**28d**	**0ed**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0d**	**0d**
1	01-Site survey & material list		1d	0ed	0	0	0	0	1	1	1	1	0d	0d
2	02-Material & equipment to site	1	3d	0ed	1	1	1	1	4	4	4	4	0d	0d
3	03-Fabricate interior wall partition [4C]	2	2d	15ed	4	4	19	19	6	21	21	21	0d	0d
4	04-Fasten wood strips to purlins [2C]	2	2d	6ed	4	4	10	14	6	12	12	16	3d	4d
5	05A-Fabricate timber trusses [4C]	2	1d	0ed	4	4	4	7	5	5	5	8	0d	3d
6	06-Excavate [4L]	2	1d	0ed	4	4	4	4	5	5	5	5	0d	0d
7	07-Fabricate exterior doors [2C]	2	2d	13ed	4	4	17	21	6	19	19	23	4d	4d
8	08A-Const. plywood ext. wall panel [4C]	2	1d	8ed	4	4	12	16	5	13	13	17	0d	4d
9	09-Forms, rebar & bolts for col ftgs [4C,2I,2L]	6	1d	0ed	5	5	5	5	6	6	6	6	0d	0d
10	10-Place drain pipes [SUB]	6	1d	0ed	5	5	5	10	6	6	6	11	5d	5d
31	05B-Fabricate timber trusses [4C]	5	3d	2ed	5	5	7	10	8	10	10	13	2d	3d
32	08B-Const. plywood ext. wall panel [4C]	8	2d	2ed	5	13	15	19	7	17	17	21	4d	4d
11	11-Pour footings [1C,2L]	9	1d	0ed	6	6	6	6	7	7	7	7	0d	0d
12	12-Strip footings [1L]	11FS+3d	1d	0ed	10	10	10	10	11	11	11	11	0d	0d
13	13-Erect steel cols & vert brace [4I]	12	1d	0ed	11	11	11	12	12	12	12	13	0d	1d
14	14-Backfill, compact & grade slab [2L]	10,12	2d	0ed	11	11	11	11	13	13	13	13	0d	0d
15	15-Erect trusses [4I]	13,31	1d	0ed	12	12	12	13	13	13	13	14	0d	1d
16	16-Forms, rebar & drains floor slab [4C,2I]	14	1d	0ed	13	13	13	13	14	14	14	14	0d	0d
17	17-Fab & erect frames @ truss pans [2C,2I]	15	1d	1ed	13	13	14	15	14	15	15	16	0d	1d
18	18-Pour slab [1C,2L]	13,16	1d	0ed	14	14	14	14	15	15	15	15	0d	0d
19	19-Erect steel purlins [4I]	4,17	1d	0ed	14	15	15	16	15	16	16	17	0d	1d
20	20-Cure slab	18	6d	0ed	15	15	15	15	21	21	21	21	0d	0d
21	21-Place red bridging & weld [4I]	19	1d	0ed	15	16	16	17	16	17	17	18	0d	1d
23	23-Nail planks to purlins [2C]	21	2d	0ed	16	17	17	18	18	19	19	20	0d	1d
26	26-Lay tar paper on planks [2L]	23	1d	0ed	18	19	19	20	19	20	20	21	0d	1d
28	28-Erect corrugated roofing [2C]	26	2d	3ed	19	20	23	24	21	25	25	26	1d	1d
22	22-Erect ext. wall panels [4C]	20,32	2d	0ed	21	21	21	21	23	23	23	23	0d	0d
29	29-Erect interior wall partitions [4C]	3,20,26	1d	4ed	21	21	25	25	22	26	26	26	0d	0d
24	24-Erect doors [2C]	7,22	1d	0ed	23	23	23	23	24	24	24	24	0d	0d
25	25-Waterproof & insulate joints [2L]	22	1d	0ed	23	23	23	23	24	24	24	24	0d	0d
27	27-Paint ext. walls [SUB]	24,25	2d	0ed	24	24	24	24	26	26	26	26	0d	0d
30	30-Cleanup [4L]	27,28,29	2d	0ed	26	26	26	26	28	28	28	28	0d	0d



ID	Resource Name	Work	Details
	Unassigned	0d	Work
1	Carpenters	78d	Work
2	Ironworkers	22d	Work
3	Laborers	27d	Work

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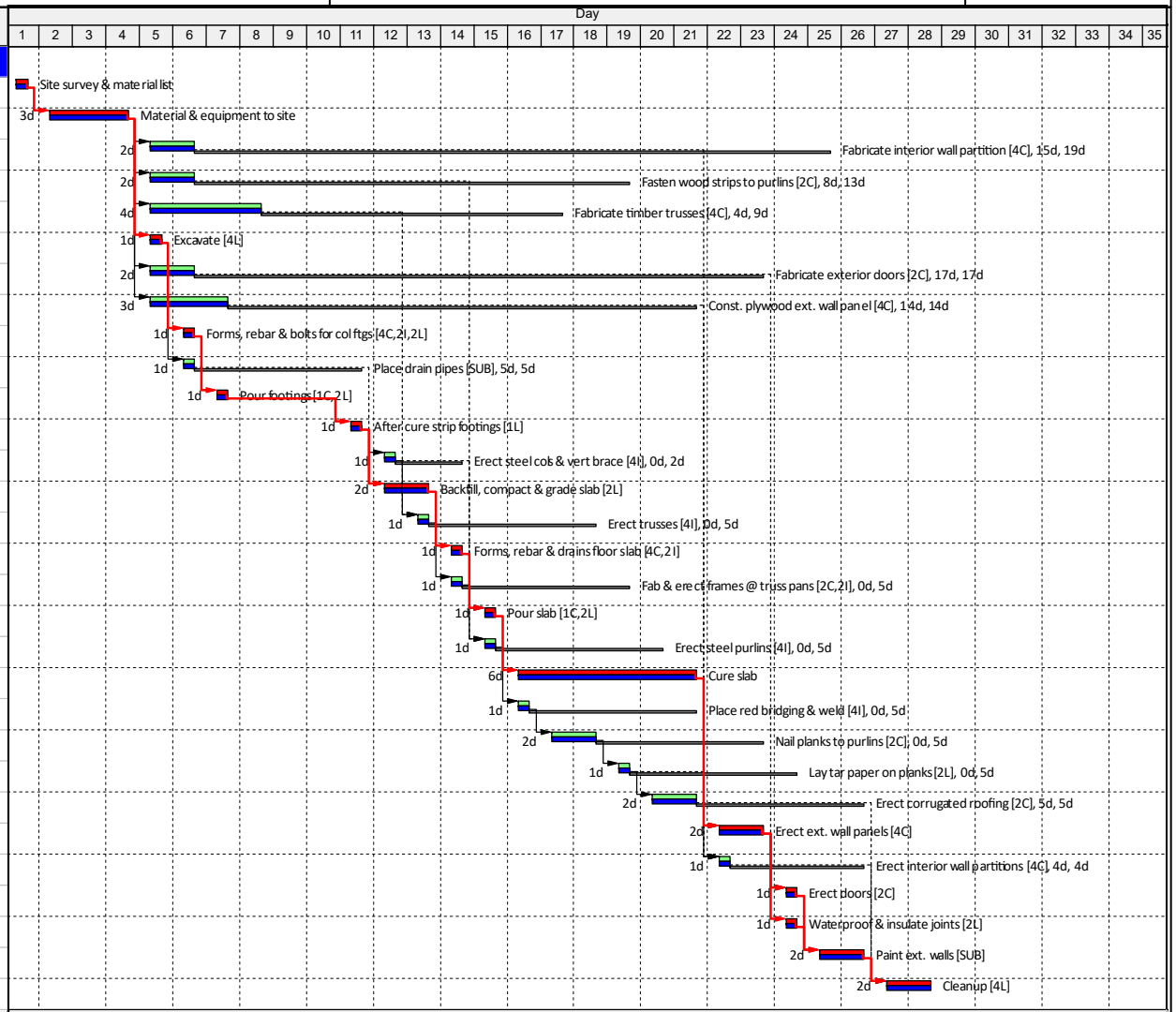
_Lab6.3_Gantt_Chart_P3_Splits-T=28
Sorted by: Preleved Start, Name

Leveled by MS Project using P3 splits - Project duration T=28d
Act 5: T5 = 4d; P3 split into: T5A = 1d, Break = 2d, T5B = 3d
Act 8: T8 = 3d; P3 split into T8A = 1d, Break = 2d, T8B = 2d

Course: CEE538
User: P.G. Ioannou

Primavera P6 Professional	Project: Warehouse-LT-Unleveled-T=28d	Layout: 2025F-Lab6.1-Unleveled	Date: 25-07-25

ID	Act	Pred	Orig Dur	Start	Finish	FF	TF
Warehouse-LT-Unleveled-T=28d			28d	01-11-25	28-11-25	0d	0d
01	Site survey & material list		1d	01-11-25	01-11-25	0d	0d
02	Material & equipment to site	01	3d	02-11-25	04-11-25	0d	0d
03	Fabricate interior wall partition [4C]	02	2d	05-11-25	06-11-25	15d	19d
04	Fasten wood strips to purlins [2C]	02	2d	05-11-25	06-11-25	8d	13d
05	Fabricate timber trusses [4C]	02	4d	05-11-25	08-11-25	4d	9d
06	Excavate [4L]	02	1d	05-11-25	05-11-25	0d	0d
07	Fabricate exterior doors [2C]	02	2d	05-11-25	06-11-25	17d	17d
08	Const. plywood ext. wall panel [4C]	02	3d	05-11-25	07-11-25	14d	14d
09	Forms, rebar & bolts for col ftgs [4C,2I,2L]	06	1d	06-11-25	06-11-25	0d	0d
10	Place drain pipes [SUB]	06	1d	06-11-25	06-11-25	5d	5d
11	Pour footings [1C,2L]	09	1d	07-11-25	07-11-25	0d	0d
12	After cure strip footings [1L]	11	1d	11-11-25	11-11-25	0d	0d
13	Erect steel cols & vert brace [4I]	12	1d	12-11-25	12-11-25	0d	2d
14	Backfill, compact & grade slab [2L]	10, 12	2d	12-11-25	13-11-25	0d	0d
15	Erect trusses [4I]	13, 05	1d	13-11-25	13-11-25	0d	5d
16	Forms, rebar & drains floor slab [4C,2I]	14	1d	14-11-25	14-11-25	0d	0d
17	Fab & erect frames @ truss pans [2C,2I]	15	1d	14-11-25	14-11-25	0d	5d
18	Pour slab [1C,2L]	13, 16	1d	15-11-25	15-11-25	0d	0d
19	Erect steel purlins [4I]	04, 17	1d	15-11-25	15-11-25	0d	5d
20	Cure slab	18	6d	16-11-25	21-11-25	0d	0d
21	Place red bridging & weld [4I]	19	1d	16-11-25	16-11-25	0d	5d
23	Nail planks to purlins [2C]	21	2d	17-11-25	18-11-25	0d	5d
26	Lay tar paper on planks [2L]	23	1d	19-11-25	19-11-25	0d	5d
28	Erect corrugated roofing [2C]	26	2d	20-11-25	21-11-25	5d	5d
22	Erect ext. wall panels [4C]	20, 08	2d	22-11-25	23-11-25	0d	0d
29	Erect interior wall partitions [4C]	03, 20, 26	1d	22-11-25	22-11-25	4d	4d
24	Erect doors [2C]	07, 22	1d	24-11-25	24-11-25	0d	0d
25	Waterproof & insulate joints [2L]	22	1d	24-11-25	24-11-25	0d	0d
27	Paint ext. walls [SUB]	24, 25	2d	25-11-25	26-11-25	0d	0d
30	Cleanup [4L]	27, 28, 29	2d	27-11-25	28-11-25	0d	0d



Activity ID	Activity Name	Start	Finish	Budgeted Units	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
Total		05-11-25	28-11-25						20	24	11	4			1	6	6	10	7	4	2	2	2	2	2	8	4	4			4	4							
	Resource ID Name: C Carpenter	05-11-25	24-11-25						16	20	9	4						6	1		2	2		2	2	8	4	2											
	Resource ID Name: I Ironworkers	06-11-25	16-11-25							2						4	4	4	4	4																			
	Resource ID Name: L Laborers	05-11-25	28-11-25						4	2	2				1	2	2		2				2					2			4	4							

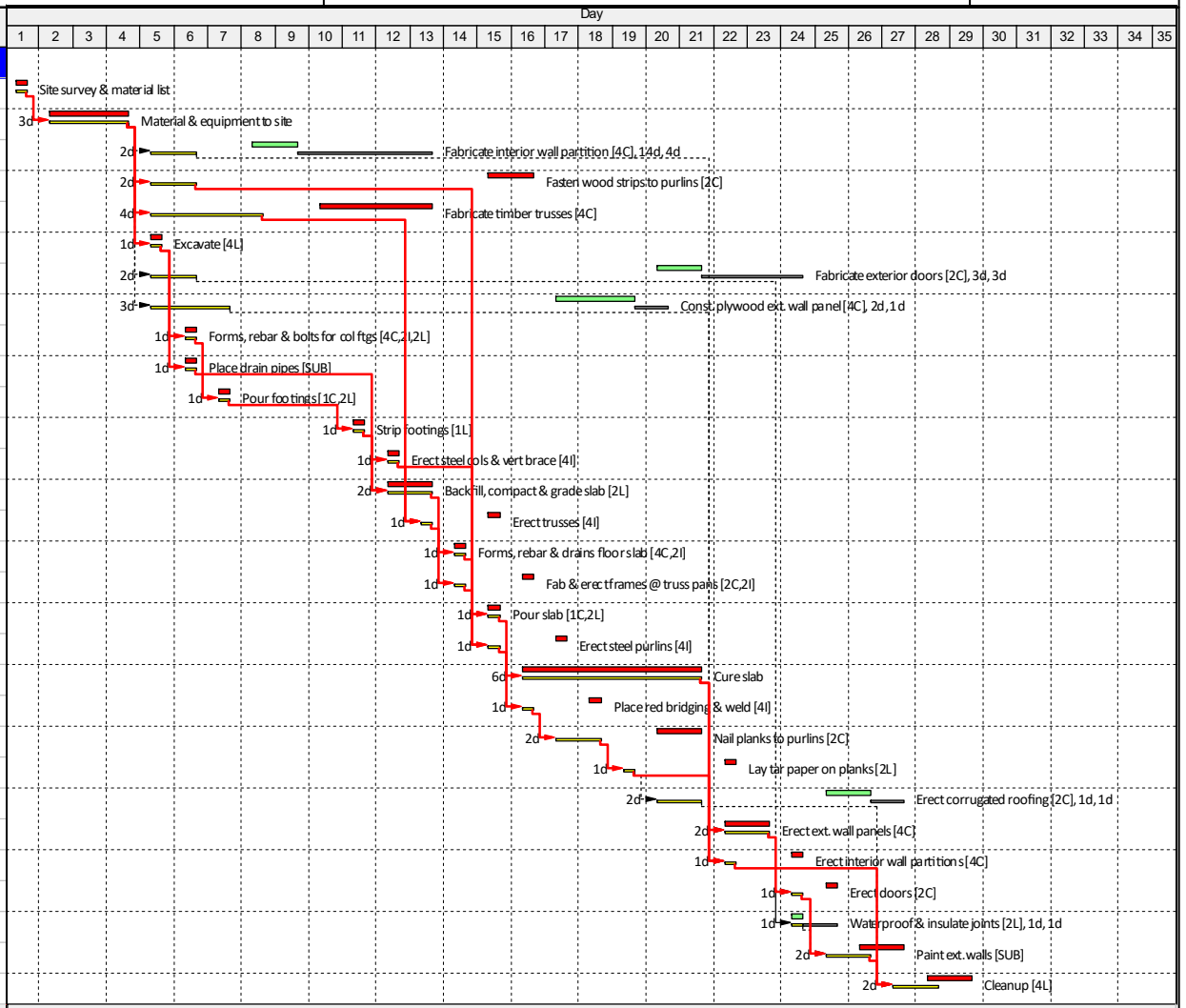
Critical Rem Work
Remaining Work
Early Bar
Float Bar

Date	Revision	Check...	Approved
01-11-25	Early-Start Schedule, Unleveled, T=28d	PGI	PGI
	(To print all 3 res rows in sprdsht, select them on screen)		
	Sorted by: Early Start, Activity ID		

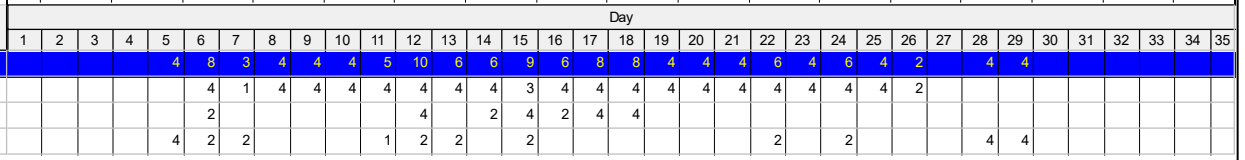
Course: CEE538
User: P.G. Ioannou

Primavera P6 Professional	Project: Warehouse-LT-No Splits-TF-Leveling-T=29d	Layout: 2025F-Lab6.2-TF Leveling-No Splits	Date: 25-07-25

ID	Act	Pred	Orig Dur	Start	Finish	FF	TF
Warehouse-LT-No Splits-TF-Leveling-T=29d			29d	01-11-25	29-11-25	0d	0d
01	Site survey & material list		1d	01-11-25	01-11-25	0d	-9d
02	Material & equipment to site	01	3d	02-11-25	04-11-25	0d	-9d
03	Fabricate interior wall partition [4C]	02	2d	08-11-25	09-11-25	14d	4d
04	Fasten wood strips to purlins [2C]	02	2d	15-11-25	16-11-25	0d	-5d
05	Fabricate timber trusses [4C]	02	4d	10-11-25	13-11-25	1d	-4d
06	Excavate [4L]	02	1d	05-11-25	05-11-25	0d	-9d
07	Fabricate exterior doors [2C]	02	2d	20-11-25	21-11-25	3d	3d
08	Const. plywood ext. wall panel [4C]	02	3d	17-11-25	19-11-25	2d	1d
09	Forms, rebar & bolts for col ftgs [4C,2I,2L]	06	1d	06-11-25	06-11-25	0d	-9d
10	Place drain pipes [SUB]	06	1d	06-11-25	06-11-25	5d	-4d
11	Pour footings [1C,2L]	09	1d	07-11-25	07-11-25	0d	-9d
12	Strip footings [1L]	11	1d	11-11-25	11-11-25	0d	-9d
13	Erect steel cols & vert brace [4I]	12	1d	12-11-25	12-11-25	2d	-3d
14	Backfill, compact & grade slab [2L]	10,12	2d	12-11-25	13-11-25	0d	-9d
15	Erect trusses [4I]	13,05	1d	15-11-25	15-11-25	0d	-5d
16	Forms, rebar & drains floor slab [4C,2I]	14	1d	14-11-25	14-11-25	0d	-9d
17	Fab & erect frames @ truss pans [2C,2I]	15	1d	16-11-25	16-11-25	0d	-5d
18	Pour slab [1C,2L]	13,16	1d	15-11-25	15-11-25	0d	-5d
19	Erect steel purlins [4I]	04,17	1d	17-11-25	17-11-25	0d	-5d
20	Cure slab	18	6d	16-11-25	21-11-25	0d	-5d
21	Place red bridging & weld [4I]	19	1d	18-11-25	18-11-25	1d	-5d
23	Nail planks to purlins [2C]	21	2d	20-11-25	21-11-25	0d	-6d
26	Lay tar paper on planks [2L]	23	1d	22-11-25	22-11-25	1d	-6d
28	Erect corrugated roofing [2C]	26	2d	25-11-25	26-11-25	1d	1d
22	Erect ext. wall panels [4C]	20,08	2d	22-11-25	23-11-25	0d	-1d
29	Erect interior wall partitions [4C]	03,20,26	1d	24-11-25	24-11-25	3d	-7d
24	Erect doors [2C]	07,22	1d	25-11-25	25-11-25	0d	0d
25	Waterproof & insulate joints [2L]	22	1d	24-11-25	24-11-25	1d	1d
27	Paint ext. walls [SUB]	24,25	2d	26-11-25	27-11-25	0d	0d
30	Cleanup [4L]	27,28,29	2d	28-11-25	29-11-25	0d	0d



Activity ID	Activity Name	Start	Finish	Budgeted Units
Total		05-11-25	29-11-25	
	Resource ID Name: C Carpenters	06-11-25	26-11-25	
	Resource ID Name: I Ironworkers	06-11-25	18-11-25	
	Resource ID Name: L Laborers	05-11-25	29-11-25	



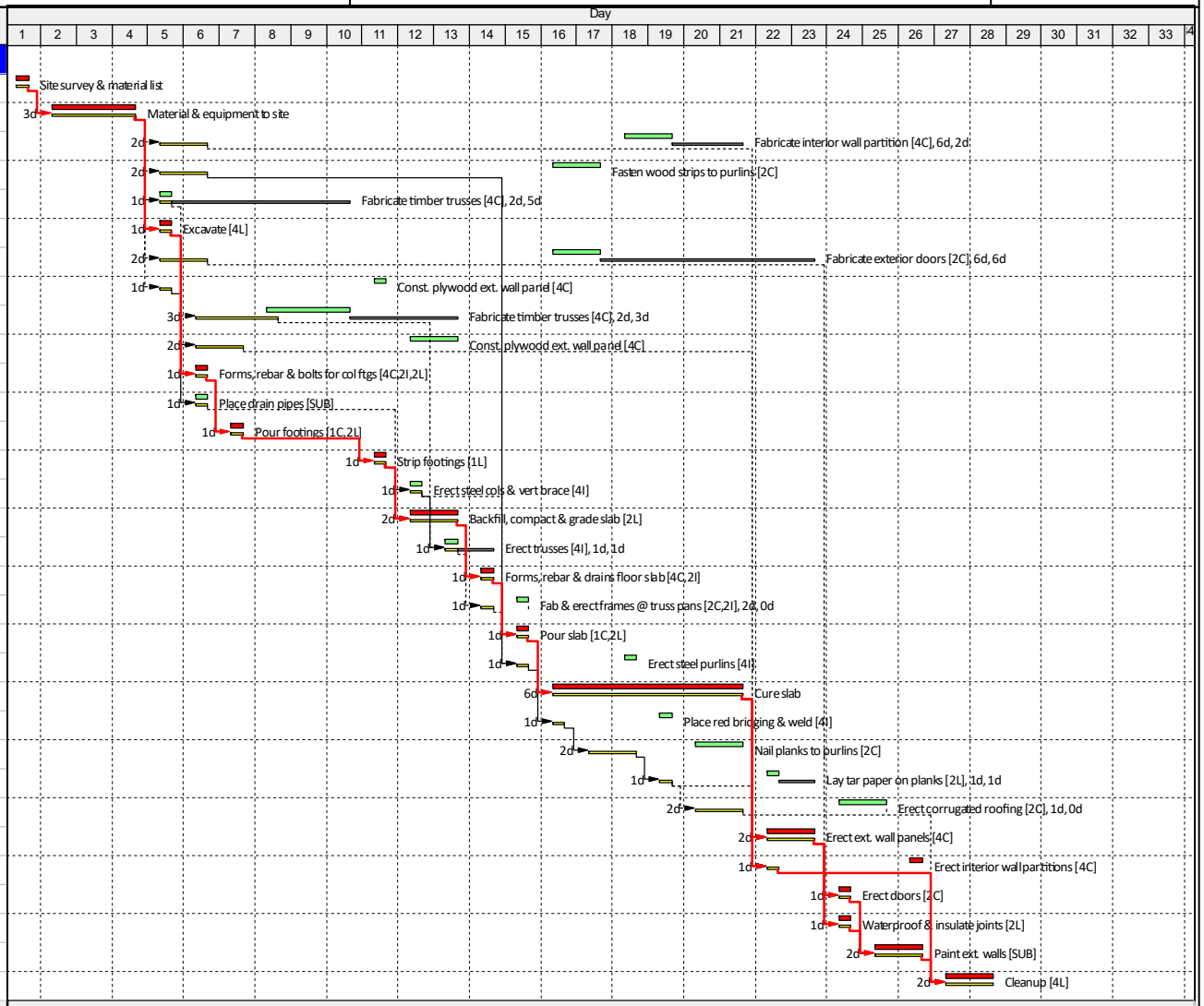
Project Baseline Bar
Float Bar
Critical Rem Work
Remaining Work

Date	Revision	Checked	Approved
01-11-25	Repeated TF-leveling by P6, No splits, T=29d	PGI	PGI
	Preserve schedule early and late dates: No		
	Sorted by: BL Early Start, Activity ID		

Course: CEE538
User: P.G. Ioannou

Primavera P6 Professional	Project: Warehouse-LT-P3 Splits-TF-leveling-T=28d	Layout: 2025F-Lab6.3-TF Leveling-P3 Splits	Date: 25-07-25

ID	Act	Pred	Orig Dur	Start	Finish	FF	TF
Warehouse-LT-P3 Splits-TF-leveling-T=28d			28d	01-11-25	28-11-25	0d	0d
01	Site survey & material list		1d	01-11-25	01-11-25	0d	-10d
02	Material & equipment to site	01	3d	02-11-25	04-11-25	0d	-10d
03	Fabricate interior wall partition [4C]	02	2d	18-11-25	19-11-25	6d	2d
04	Fasten wood strips to purlins [2C]	02	2d	16-11-25	17-11-25	0d	-2d
05A	Fabricate timber trusses [4C]	02	1d	05-11-25	05-11-25	2d	5d
06	Excavate [4L]	02	1d	05-11-25	05-11-25	0d	-10d
07	Fabricate exterior doors [2C]	02	2d	16-11-25	17-11-25	6d	6d
08A	Const. plywood ext. wall panel [4C]	02	1d	11-11-25	11-11-25	0d	-4d
05B	Fabricate timber trusses [4C]	05A	3d	08-11-25	10-11-25	2d	3d
08B	Const. plywood ext. wall panel [4C]	08A	2d	12-11-25	13-11-25	8d	-4d
09	Forms, rebar & bolts for col ftgs [4C,2I,2L]	06	1d	06-11-25	06-11-25	0d	-10d
10	Place drain pipes [SUB]	06	1d	06-11-25	06-11-25	5d	-5d
11	Pour footings [1C,2L]	09	1d	07-11-25	07-11-25	0d	-10d
12	Strip footings [1L]	11	1d	11-11-25	11-11-25	0d	-10d
13	Erect steel cols & vert brace [4I]	12	1d	12-11-25	12-11-25	0d	-7d
14	Backfill, compact & grade slab [2L]	10,12	2d	12-11-25	13-11-25	0d	-10d
15	Erect trusses [4I]	13,05B	1d	13-11-25	13-11-25	1d	1d
16	Forms, rebar & drains floor slab [4C,2I]	14	1d	14-11-25	14-11-25	0d	-10d
17	Fab & erect frames @ truss pans [2C,2I]	15	1d	15-11-25	15-11-25	2d	0d
18	Pour slab [1C,2L]	13,16	1d	15-11-25	15-11-25	0d	-9d
19	Erect steel purlins [4I]	04,17	1d	18-11-25	18-11-25	0d	-2d
20	Cure slab	18	6d	16-11-25	21-11-25	0d	-6d
21	Place red bridging & weld [4I]	19	1d	19-11-25	19-11-25	0d	-2d
23	Nail planks to purlins [2C]	21	2d	20-11-25	21-11-25	0d	-2d
26	Lay tar paper on planks [2L]	23	1d	22-11-25	22-11-25	1d	1d
28	Erect corrugated roofing [2C]	26	2d	24-11-25	25-11-25	1d	0d
22	Erect ext. wall panels [4C]	20,08B	2d	22-11-25	23-11-25	0d	-6d
29	Erect interior wall partitions [4C]	03,20,26	1d	26-11-25	26-11-25	0d	0d
24	Erect doors [2C]	07,22	1d	24-11-25	24-11-25	0d	0d
25	Waterproof & insulate joints [2L]	22	1d	24-11-25	24-11-25	0d	0d
27	Paint ext. walls [SUB]	24,25	2d	25-11-25	26-11-25	0d	0d
30	Cleanup [4L]	27,28,29	2d	27-11-25	28-11-25	0d	0d



Activity ID	Activity Name	Start	Finish	Budgeted Units
Total		05-11-25	28-11-25	
	Resource ID Name: C Carpenters	05-11-25	26-11-25	
	Resource ID Name: I Ironworkers	06-11-25	19-11-25	
	Resource ID Name: L Laborers	05-11-25	28-11-25	

Day	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33
Total					8	8	3	4	4	4	5	10	10	6	7	4	4	8	8	2	2	6	4	6	2	4	4	4					
Resource ID Name: C Carpenters					4	4	1	4	4	4	4	4	4	4	3	4	4	4	4	2	2	4	4	4	2	4							
Resource ID Name: I Ironworkers						2						4	4	2	2			4	4														
Resource ID Name: L Laborers					4	2	2				1	2	2		2							2		2			4	4					

Project Baseline Bar
Critical Rem Work
Remai...
Float Bar

Repeated TF-leveling by P6: T= 28d; using P3 splits: 'Act 5(4d) = 5A(1d) & 5B(3d)'; 'Act 8(3d) = 8A(1d) & 8B(2d)'
Set: "Preserve scheduled early and late dates": No; "Leveling Priorities": "Total Float (Ascending)"
Sorted by: BS Early Start, Activity ID

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