## 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 | 12A | 12A-Cure & strip footings (start) | 3 | 11 | - |
| 13 | 13 | 13-Erect steel cols & vert brace [4I] | 1 | 12B | 4I |
| 14 | 14 | 14-Backfill, compact & grade slab [2L] | 2 | 10,12B | 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 |
| 31 | 12B | 12B-Cure & strip footings (end) [1L] | 1 | 12A | 1L |

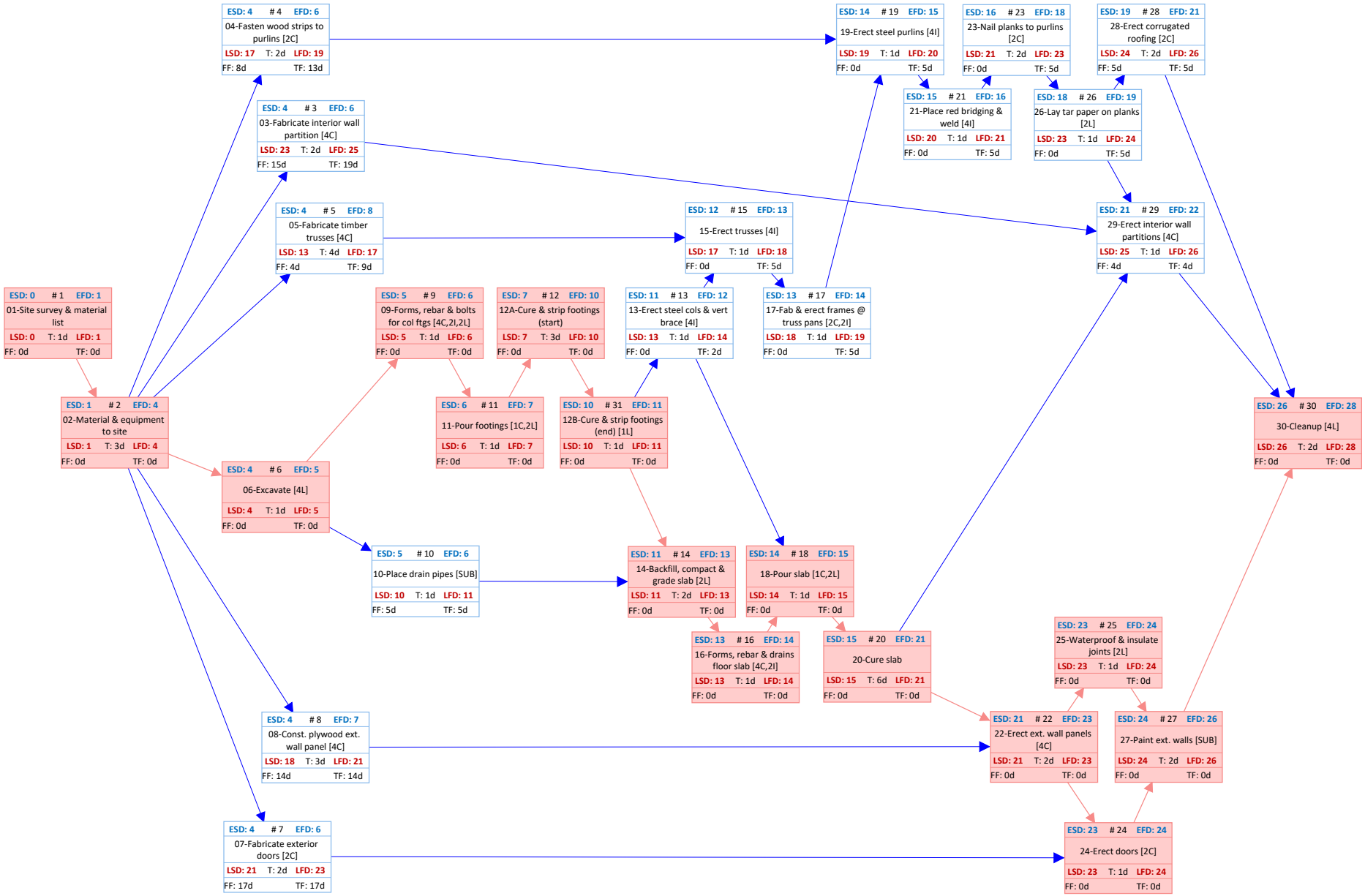
MSP ID: Activity ID numbers to use in MS Project Pro (consecutive numbers).
P6 ID: Activity ID numbers to use in P6 Pro (similar to the numbers used by Fondahl, P3, and Suretrak).

Note: The original Warehouse Project had only 30 activities, but also specified the following for activity 12:

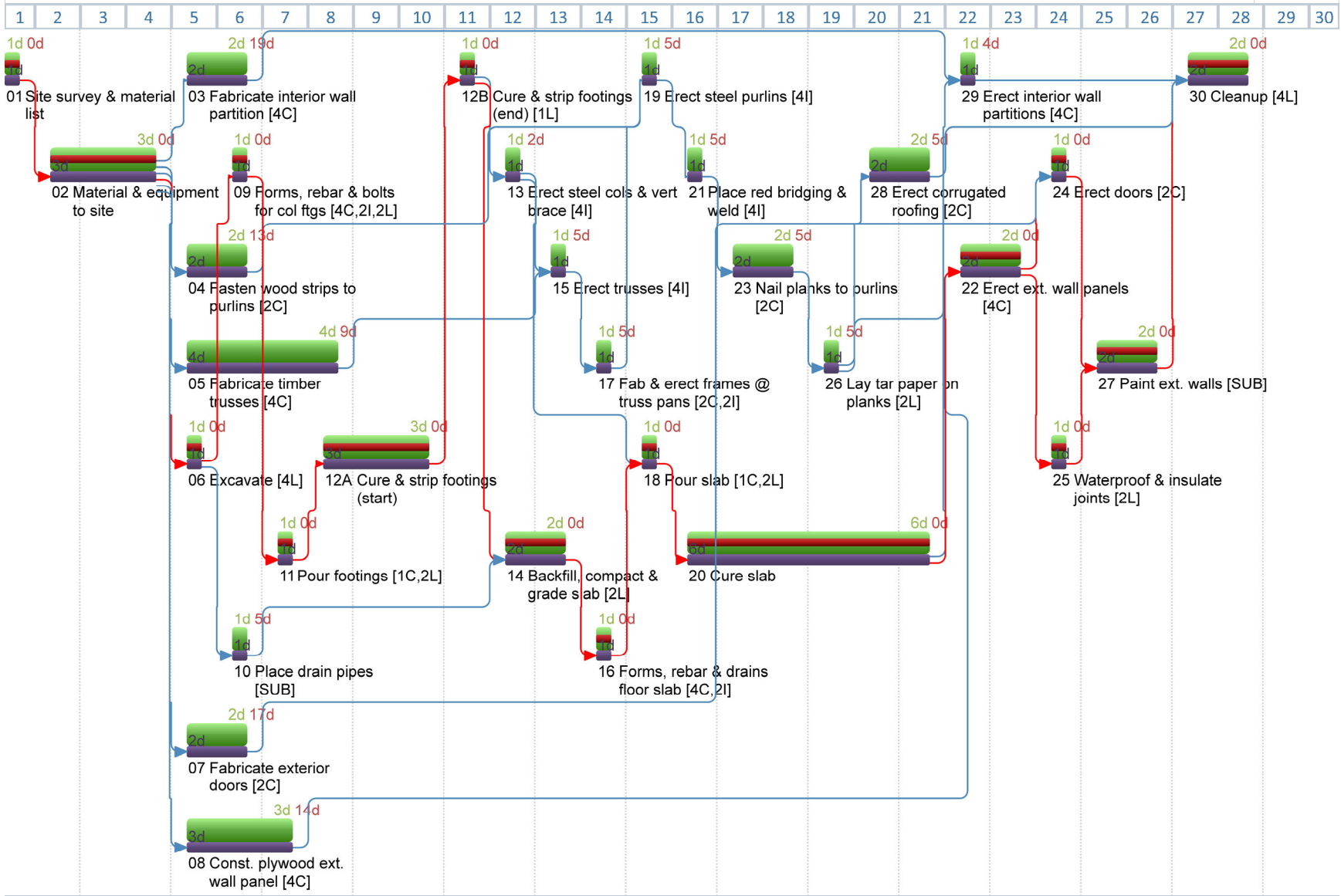
- "12 - Cure and strip footings"; T=4d; uses 1 Laborer, but only on the 4th day to strip the formwork.

This is modeled in Tables 1 & 2 by splitting activity 12 into two activities (with different resources) as follows:

- "12 or 12A - Cure and strip footings (start)"; T=3d (i.e., "Cure Footings"; no resources) and
- "31 or 12B - Cure and strip footings (end)"; T=1d (i.e., "Strip Footings"; 1L)


ESD: 0 # 1 EFD: 1
01-Site survey & material list
LSD: 0 T: 1d LFD: 1
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: 1 # 2 EFD: 4
02-Material & equipment to site
LSD: 1 T: 3d LFD: 4
FF: 0d TF: 0d
ESD: 4 # 6 EFD: 5
06-Excavate [4L]
LSD: 4 T: 1d LFD: 5
FF: 0d TF: 0d
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: 6 # 11 EFD: 7
11-Pour footings [1C,2L]
LSD: 6 T: 1d LFD: 7
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: 10 # 31 EFD: 11
12B-Cure & strip footings (end) [1L]
LSD: 10 T: 1d LFD: 11
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: 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: 12 # 15 EFD: 13
15-Erect trusses [4I]
LSD: 17 T: 1d LFD: 18
FF: 0d TF: 5d
ESD: 11 # 13 EFD: 12
13-Erect steel cols & vert brace [4I]
LSD: 13 T: 1d LFD: 14
FF: 0d TF: 2d
ESD: 13 # 17 EFD: 14
17-Fab & erect frames @ truss pans [2C,2I]
LSD: 18 T: 1d LFD: 19
FF: 0d 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: 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: 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

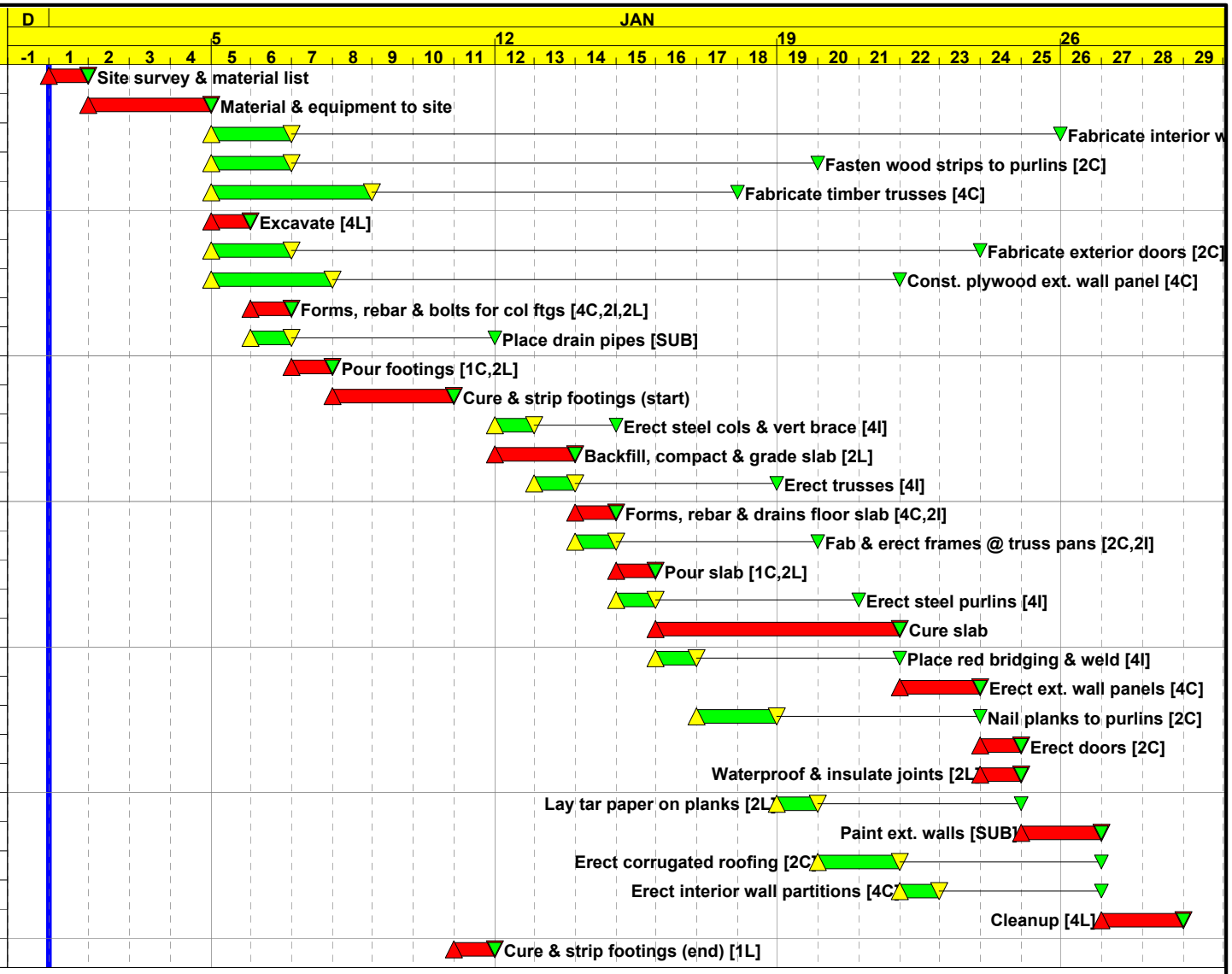
Primavera P6 Professional | 08-12-21



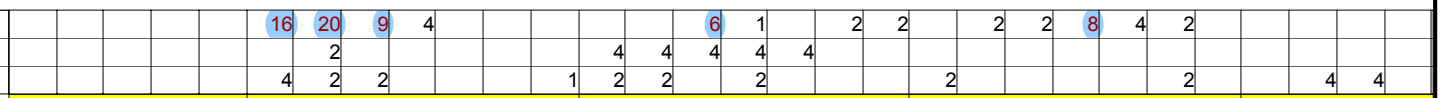

| ID | Resource Name | Work | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Unassigned | 0d | | | | | | | | | | | | | | | | | | | | | | | | |
| 1 | **Carpenters** | **78d** | 16d | 20d | 9d | 4d | | | | | | 6d | 1d | | 2d | 2d | | 2d | 2d | 8d | 4d | 2d | | | | |
| 3 | Laborers | 27d | 4d | 2d | 2d | | | | 1d | 2d | 2d | | 2d | | | | 2d | | | | | 2d | | | 4d | 4d |
| 2 | Ironworkers | 22d | | 2d | | | | | | 4d | 4d | 4d | 4d | 4d | | | | | | | | | | | | |

Course: CEE536 - CEE538 | Time-Scaled Logic Diagram | User: P.G. Ioannou

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




| Row | Group Name |
|---|---|
| 1 | Carpenters |
| 2 | Ironworkers |
| 3 | Laborers |




Start Date 01JAN98
Finish Date 28JAN98
Data Date 01JAN98
Run Date 19JUN03 14:35

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Early Bar
Float Bar
Progress Bar
Critical Activity

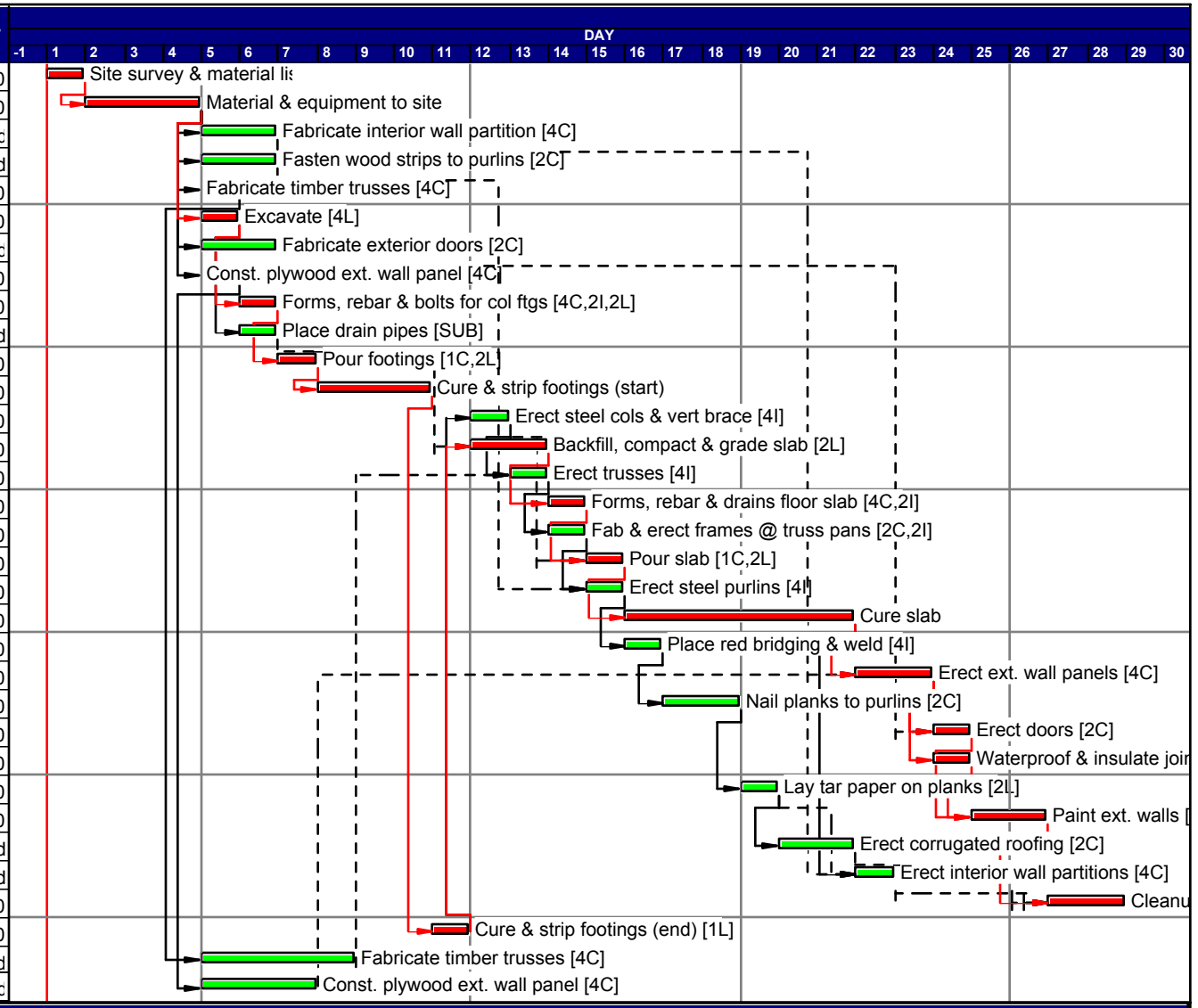
WARE Sheet 1 of 1

Warehouse Project (in P3)
28-day Orig. Schedule (Before Change Order)
Avail. Res.: 4Carpenters.,4Ironworkers, 4Laborers
Notice: Carpenters needed >> 4 Carp. available

C.O. changes Act. Durations (dT):
T3 = 2 + 6 = 8 (dT=6 < FF=15)
T7 = 2 + 5 = 7 (dT=5 < FF=17)
T8 = 3 + 9 = 12 (dT=9 < FF=14)
T29 = 1 + 3 = 4 (dT=3 < FF=4)

Because all Change Order
dT < Avail. FF,
the project owner refuses
to grant any time extension.

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




| ID | Description | Units | Display: Quantity |
|---|---|---|---|
| C | Carpenters | CA | 16 20 9 4 6 1 2 2 2 2 8 4 2 |
| I | Ironworkers | IW | 2 4 4 4 4 4 |
| L | Laborers | LB | 4 2 2 1 2 2 2 2 4 4 |

-1 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
DAY

| | |
|---|---|
| Start date | 01JAN98 |
| Finish date | 28JAN98 |
| Data date | 01JAN98 |
| Run date | 19JUN03 |
| Page number | 1A |
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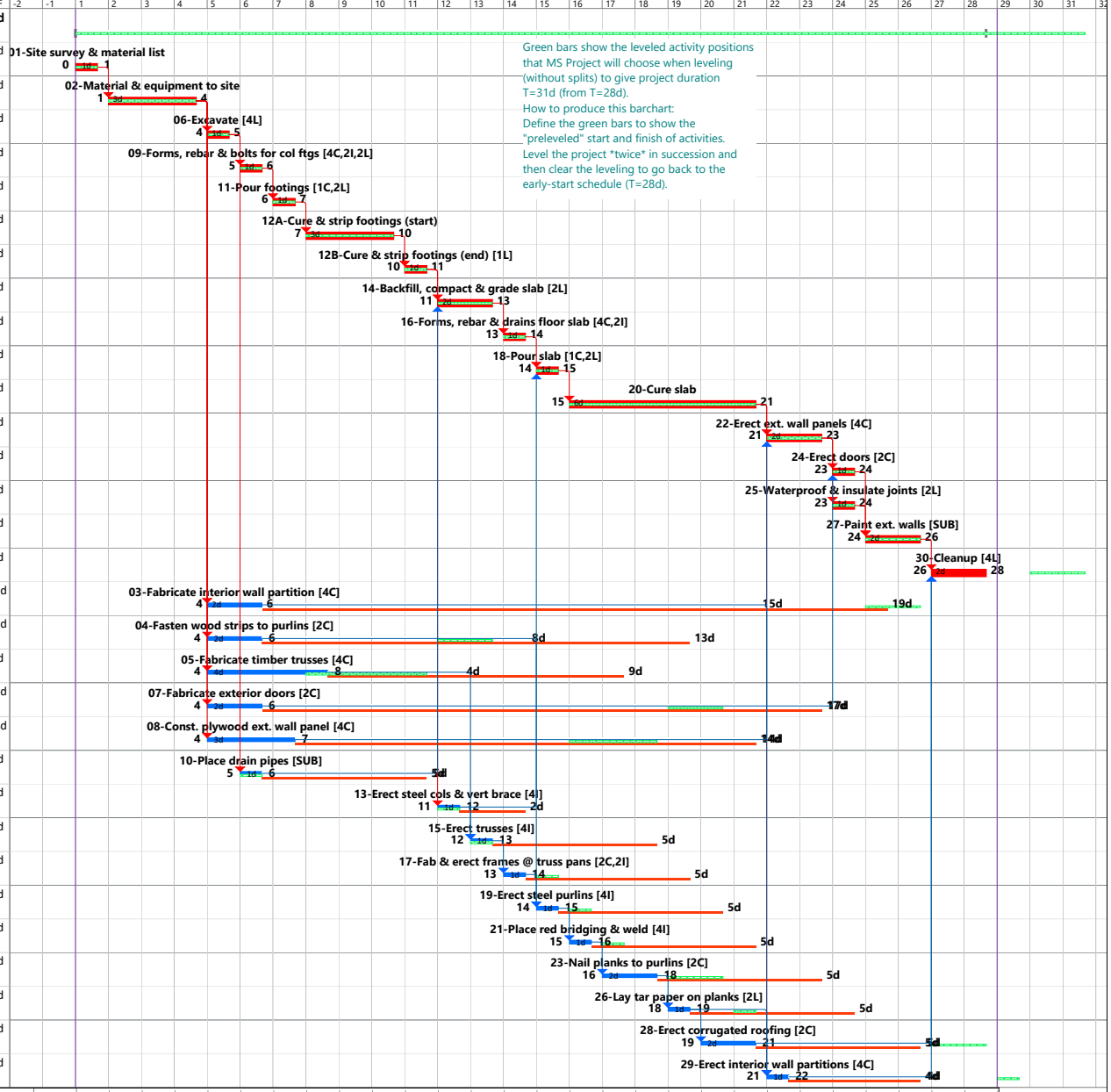
Warehouse Project (Before Change Order)
SureTrak, NoLeveling: T = 28 d
Avail. Res.: 4C,4I, 4L
Notice: Needed C >> 4

C.O. changes Act. Durations (dT):
T3 = 2 + 6 = 8 (dT=6 < FF=15)
T7 = 2 + 5 = 7 (dT=5 < FF=17)
T8 = 3 + 9 = 12 (dT=9 < FF=14)
T29 = 1 + 3 = 4 (dT=3 < FF=4)

Early bar
Progress bar
Critical bar
Summary bar
Start milestone point
Finish milestone poin

MS Project Pro | Project: Warehouse Project | Date: 11/12/21

| ID | Act | Pred | T | Lev | ESD | TSD | LSD | EFD | TFD | 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 |
| 6 | 06-Excavate [4L] | 2 | 1d | 0ed | 4 | 4 | 4 | 5 | 5 | 5 | 0d | 0d |
| 9 | 09-Forms, rebar & bolts for col ftgs [4C,2I,2L] | 6 | 1d | 0ed | 5 | 5 | 5 | 6 | 6 | 6 | 0d | 0d |
| 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 |
| 14 | 14-Backfill, compact & grade slab [2L] | 10,31 | 2d | 0ed | 11 | 11 | 11 | 13 | 13 | 13 | 0d | 0d |
| 16 | 16-Forms, rebar & drains floor slab [4C,2I] | 14 | 1d | 0ed | 13 | 13 | 13 | 14 | 14 | 14 | 0d | 0d |
| 18 | 18-Pour slab [1C,2L] | 13,16 | 1d | 0ed | 14 | 14 | 14 | 15 | 15 | 15 | 0d | 0d |
| 20 | 20-Cure slab | 18 | 6d | 0ed | 15 | 15 | 15 | 21 | 21 | 21 | 0d | 0d |
| 22 | 22-Erect ext. wall panels [4C] | 20,8 | 2d | 0ed | 21 | 21 | 21 | 23 | 23 | 23 | 0d | 0d |
| 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 | 26 | 26 | 28 | 28 | 28 | 0d | 0d |
| 3 | 03-Fabricate interior wall partition [4C] | 2 | 2d | 0ed | 4 | 4 | 23 | 6 | 6 | 25 | 15d | 19d |
| 4 | 04-Fasten wood strips to purlins [2C] | 2 | 2d | 0ed | 4 | 4 | 17 | 6 | 6 | 19 | 8d | 13d |
| 5 | 05-Fabricate timber trusses [4C] | 2 | 4d | 0ed | 4 | 4 | 13 | 8 | 8 | 17 | 4d | 9d |
| 7 | 07-Fabricate exterior doors [2C] | 2 | 2d | 0ed | 4 | 4 | 21 | 6 | 6 | 23 | 17d | 17d |
| 8 | 08-Const. plywood ext. wall panel [4C] | 2 | 3d | 0ed | 4 | 4 | 18 | 7 | 7 | 21 | 14d | 14d |
| 10 | 10-Place drain pipes [SUB] | 6 | 1d | 0ed | 5 | 5 | 10 | 6 | 6 | 11 | 5d | 5d |
| 13 | 13-Erect steel cols & vert brace [4I] | 31 | 1d | 0ed | 11 | 11 | 13 | 12 | 12 | 14 | 0d | 2d |
| 15 | 15-Erect trusses [4I] | 13,5 | 1d | 0ed | 12 | 12 | 17 | 13 | 13 | 18 | 0d | 5d |
| 17 | 17-Fab & erect frames @ truss pans [2C,2I] | 15 | 1d | 0ed | 13 | 13 | 18 | 14 | 14 | 19 | 0d | 5d |
| 19 | 19-Erect steel purlins [4I] | 4,17 | 1d | 0ed | 14 | 14 | 19 | 15 | 15 | 20 | 0d | 5d |
| 21 | 21-Place red bridging & weld [4I] | 19 | 1d | 0ed | 15 | 15 | 20 | 16 | 16 | 21 | 0d | 5d |
| 23 | 23-Nail planks to purlins [2C] | 21 | 2d | 0ed | 16 | 16 | 21 | 18 | 18 | 23 | 0d | 5d |
| 26 | 26-Lay tar paper on planks [2L] | 23 | 1d | 0ed | 18 | 18 | 23 | 19 | 19 | 24 | 0d | 5d |
| 28 | 28-Erect corrugated roofing [2C] | 26 | 2d | 0ed | 19 | 19 | 24 | 21 | 21 | 26 | 5d | 5d |
| 29 | 29-Erect interior wall partitions [4C] | 3,20,26 | 1d | 0ed | 21 | 21 | 25 | 22 | 22 | 26 | 4d | 4d |

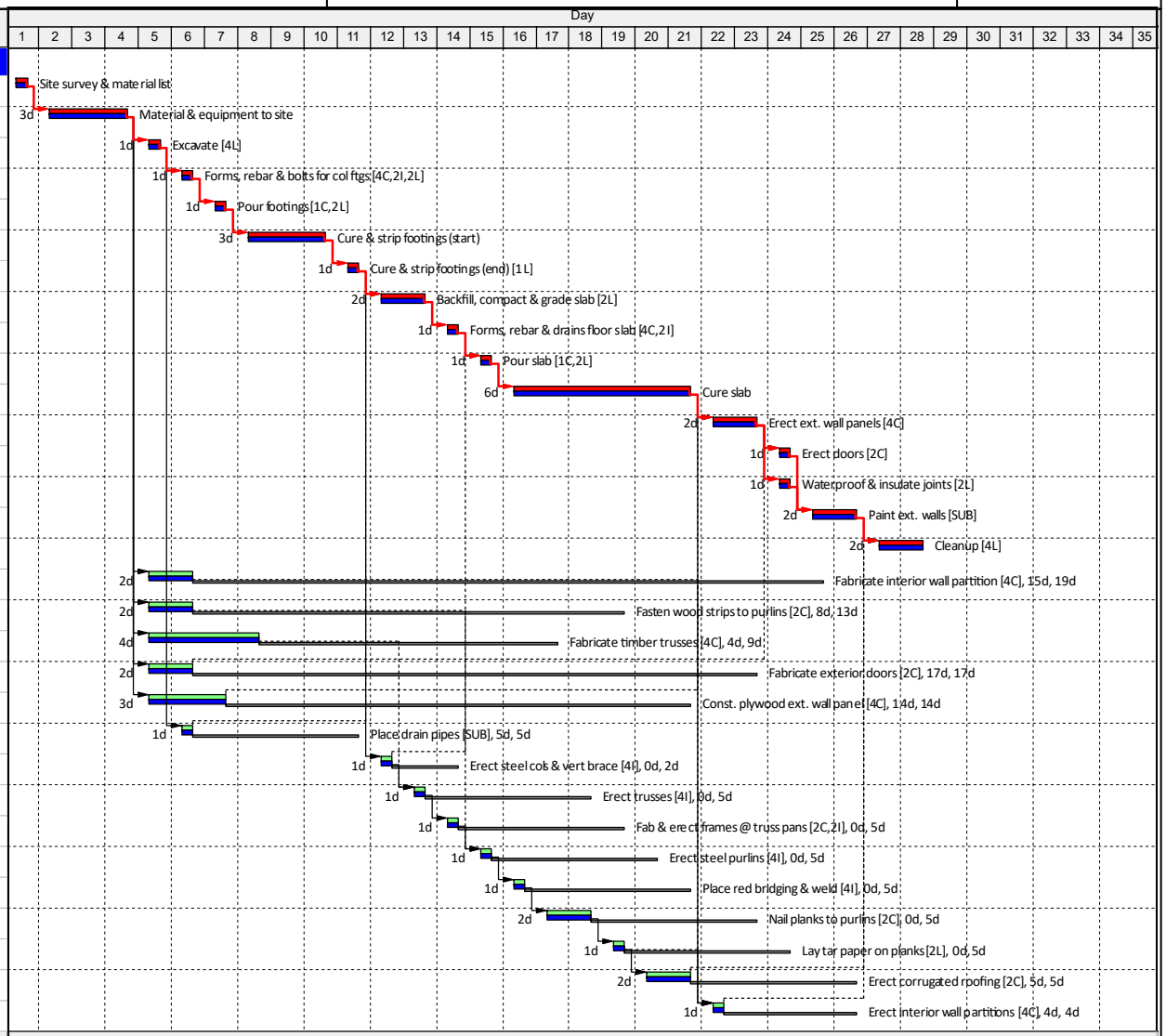



Note: The Resource Usage spreadsheet, shown on the right, was printed to pdf separately and was pasted to the pdf for the Gantt Chart using "Bluebeam Revu". If you find this too difficult, you can print and submit the two reports separately.

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

| Primavera P6 Professional R20.12 | Project: Warehouse-30+1 Acts-Unleveled-T=28d | Layout: 2021F-Lab6.1-Unleveled | Date: 30-11-21 |
|---|---|---|---|

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



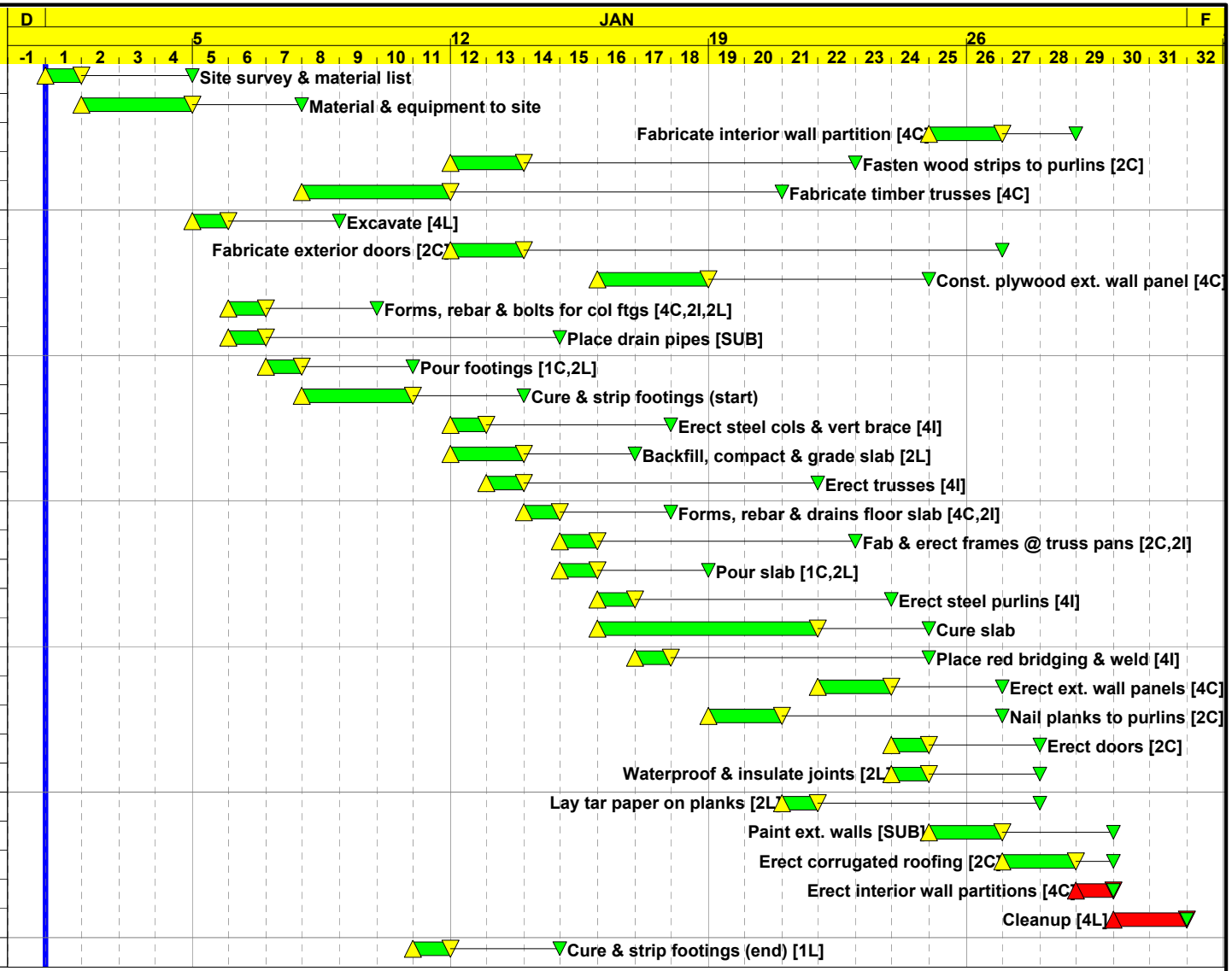

| Activity ID | Activity Name | Start | Finish | Remaining Units | Day 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 |
|---|---|---|---|---|---|
| **Total** | | 05-11-21 | 28-11-21 | | 20 24 11 4 1 6 6 10 7 4 2 2 2 2 2 8 4 4 4 4 |
| Resource ID Name: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

Critical Rem Work
Remaining Work
Early Bar
Float Bar

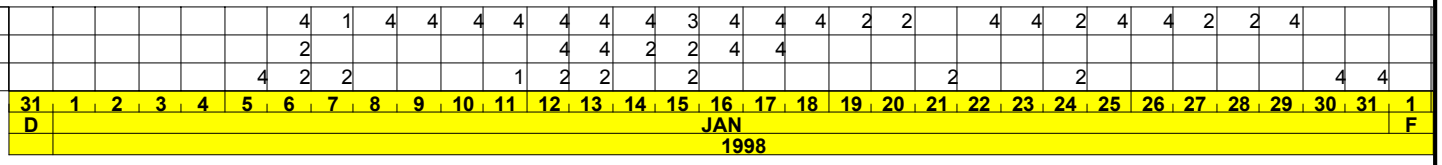
| Date | Revision | Check... | Approved |
|---|---|---|---|
| 11-14-21 | Early-Start Schedule, Unleveled, T=28d | PGI | PGI |
| | (To print all 3 res rows in sprdsht, select them on screen) | | |
| | Sorted by: Critical, Early Start, Activity ID | | |

Course: CEE538
User: P.G. Ioannou

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




| Row | Group Name |
|---|---|
| 1 | Carpenters |
| 2 | Ironworkers |
| 3 | Laborers |




Start Date 01JAN98
Finish Date 31JAN98
Data Date 01JAN98
Run Date 19JUN03 15:18

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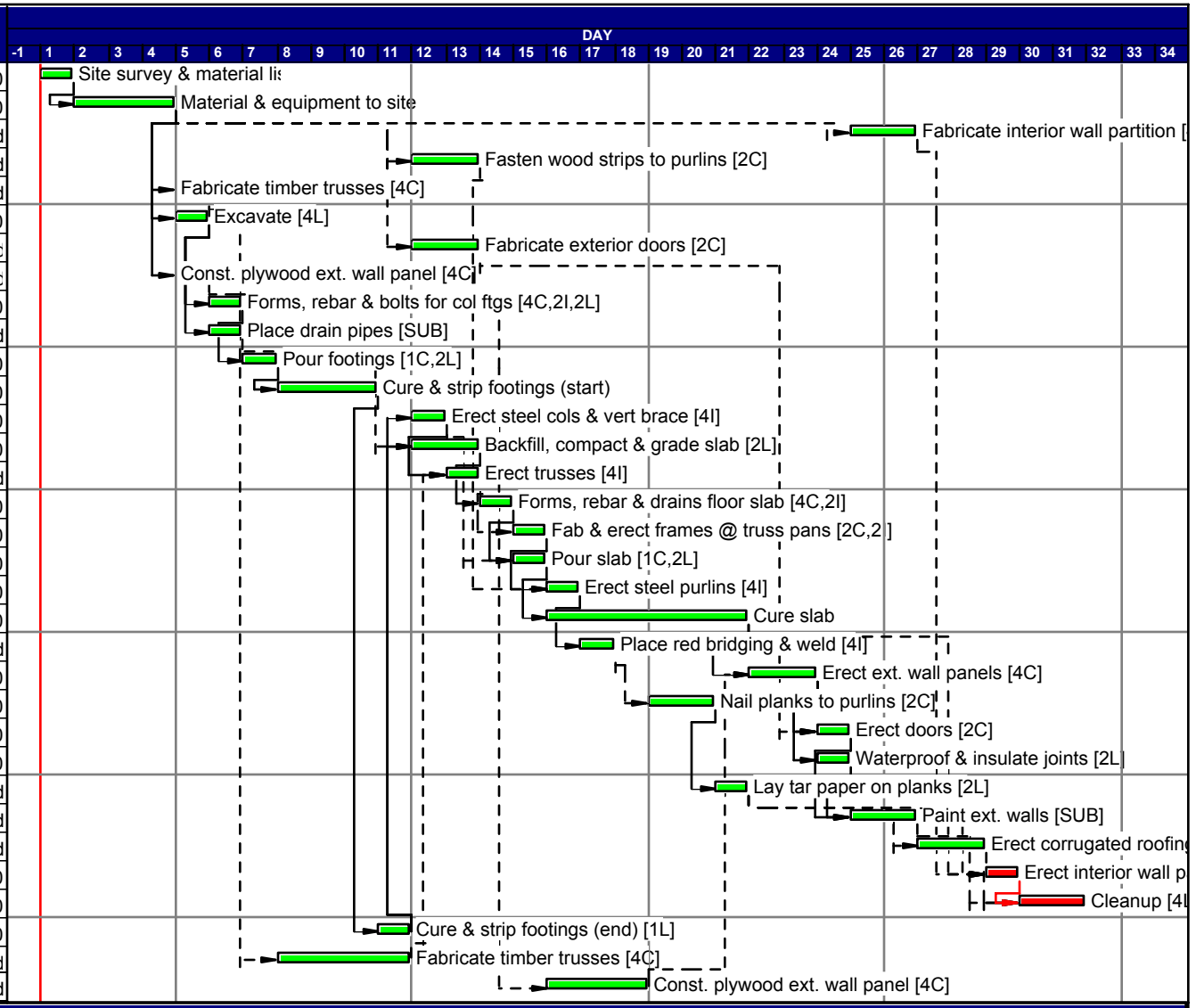
Early Bar
Float Bar
Progress Bar
Critical Activity

WARE Sheet 1 of 1

Warehouse Project
Original Activity Durations
Leveled by P3, No Splits: T=31 days

Fondahl found the same result using P3 and no splits

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




| ID | Description | Units | Total | Display: Quantity |
|---|---|---|---|---|
| C | Carpenters | CA | 78 | 4 1 4 4 4 4 4 4 4 3 4 4 4 2 2 4 4 2 4 4 2 2 4 |
| I | Ironworkers | IW | 22 | 2 4 4 2 2 4 4 |
| L | Laborers | LB | 27 | 4 2 2 1 2 2 2 2 2 4 4 |
| Total | | | | 0 0 0 0 0 4 8 3 4 4 4 5 * * 6 7 8 8 4 2 2 2 4 4 4 4 4 2 2 4 4 4 0 0 0 |



| | |
|---|---|
| Start date | 01JAN98 |
| Finish date | 31JAN98 |
| Data date | 01JAN98 |
| Run date | 19JUN03 |
| Page number | 1A |
| © Primavera Systems, Inc. | |

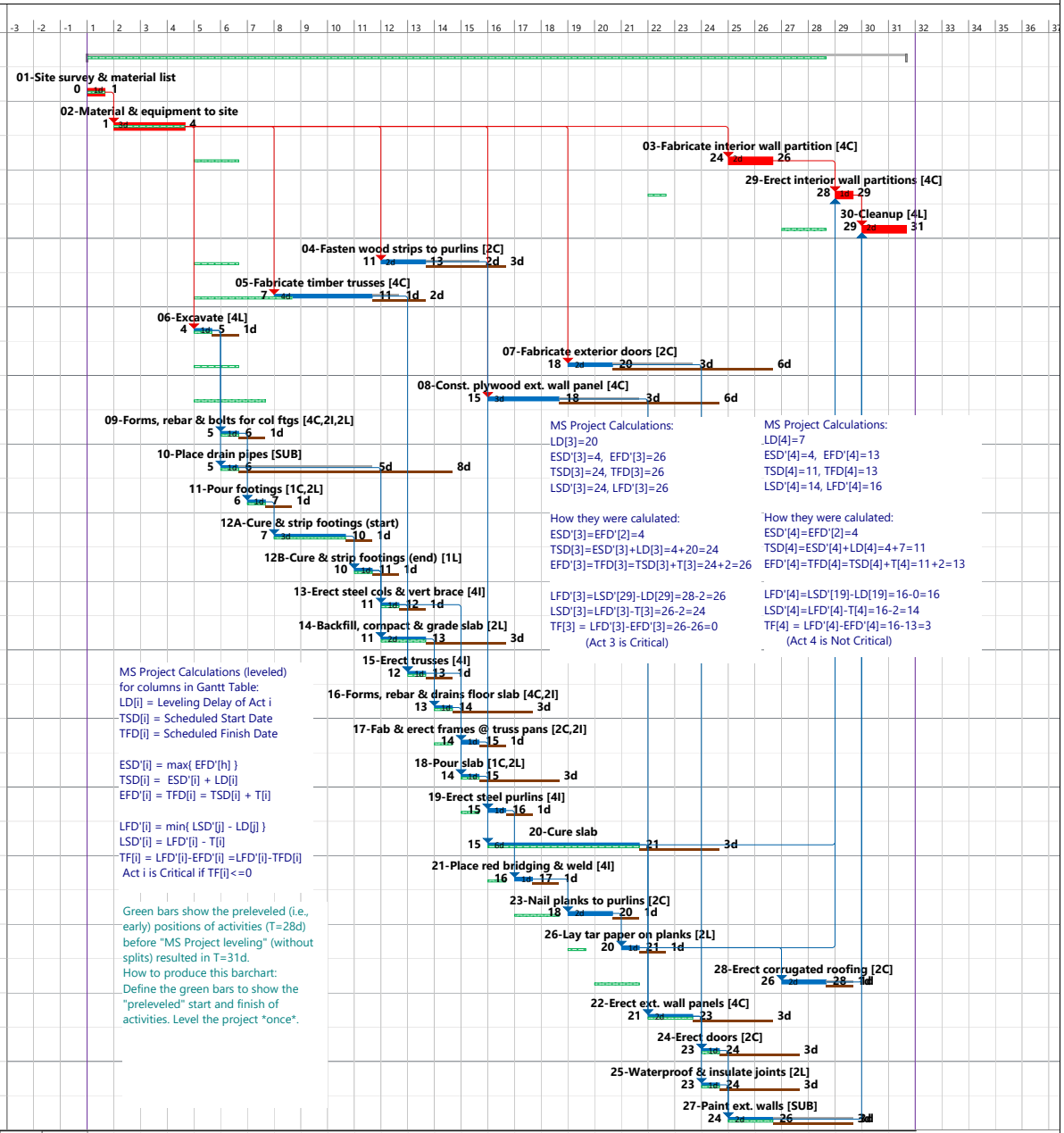
Warehouse Project (Before Change Order)
Levelled by SureTrak, No Splits: T = 31 days
(No Splits: T5=0, T5B=4, T8 = 0, T8B= 3 )

Same as P3 and Fondahl without splitting

Early bar
Progress bar
Critical bar
Summary bar
Start milestone point
Finish milestone poin

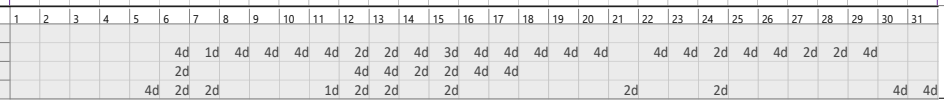
MS Project Pro | Project: Warehouse Project | Date: 11/14/21

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




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 |



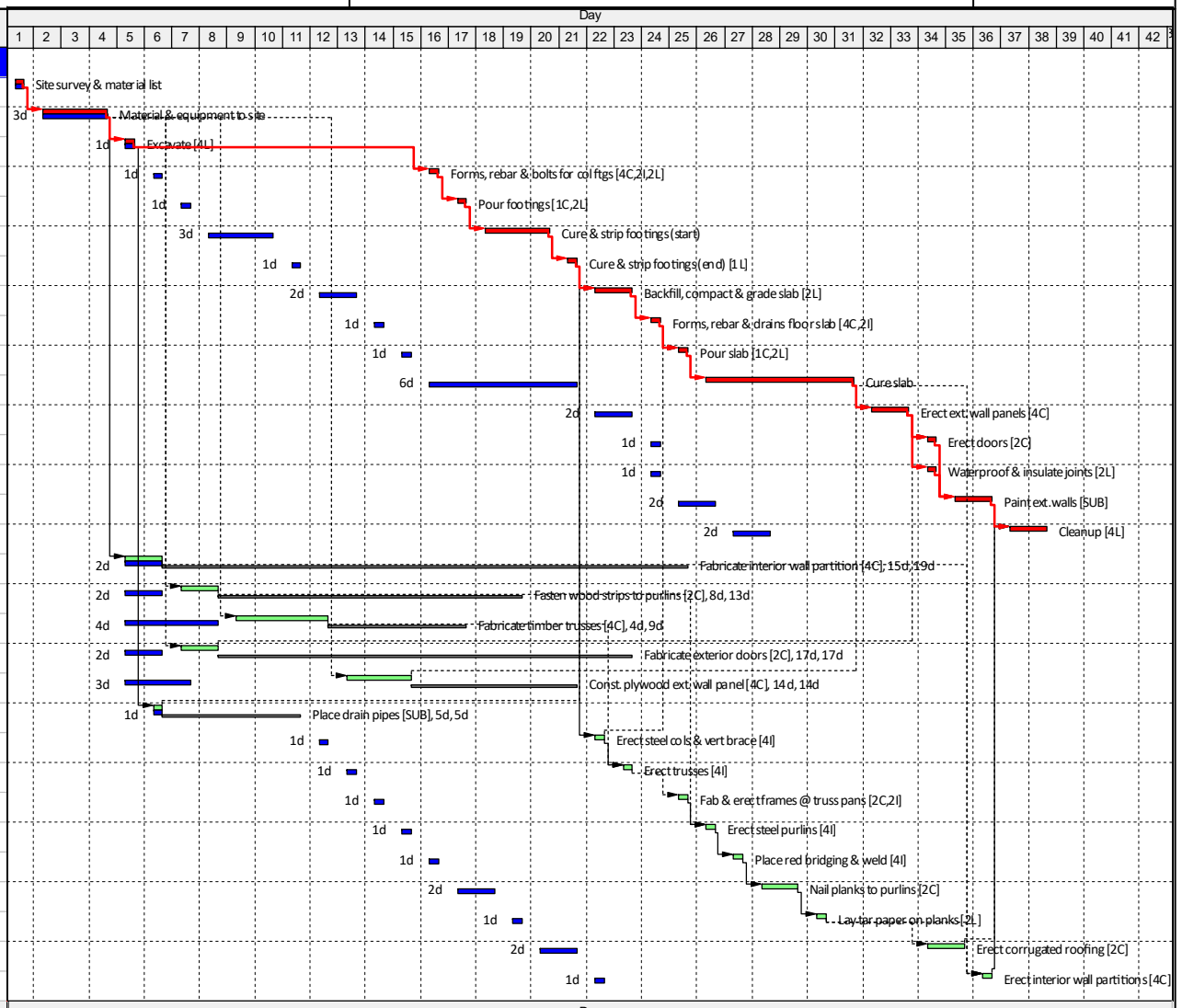
_Lab6 Gantt Chart - No Splits
Sorted by: Critical, Preleveled Start, Name

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

Course: CEE538
User: P.G. Ioannou

| Primavera P6 Professional R20.12 | Project: Warehouse-No Splits-Default-Leveling-T=38d | Layout: 2021F-Lab6.2-Default Leveling-No Splits | Date: 08-12-21 |
|---|---|---|---|

| ID | Act | Pred | Orig Dur | Start | Finish | FF | TF |
|---|---|---|---|---|---|---|---|
| **Warehouse-No Splits-Default-Leveling-T:** | | | 38d | 01-11-21 | 08-12-21 | 0d | 0d |
| 01 | Site survey & material list | | 1d | 01-11-21 | 01-11-21 | 0d | 0d |
| 02 | Material & equipment to site | 01 | 3d | 02-11-21 | 04-11-21 | 0d | 0d |
| 06 | Excavate [4L] | 02 | 1d | 05-11-21 | 05-11-21 | 0d | 0d |
| 09 | Forms, rebar & bolts for col ftgs [4C,2I,2L] | 06 | 1d | 16-11-21 | 16-11-21 | 0d | 0d |
| 11 | Pour footings [1C,2L] | 09 | 1d | 17-11-21 | 17-11-21 | 0d | 0d |
| 12A | Cure & strip footings (start) | 11 | 3d | 18-11-21 | 20-11-21 | 0d | 0d |
| 12B | Cure & strip footings (end) [1L] | 12A | 1d | 21-11-21 | 21-11-21 | 0d | 0d |
| 14 | Backfill, compact & grade slab [2L] | 10, 12B | 2d | 22-11-21 | 23-11-21 | 0d | 0d |
| 16 | Forms, rebar & drains floor slab [4C,2I] | 14 | 1d | 24-11-21 | 24-11-21 | 0d | 0d |
| 18 | Pour slab [1C,2L] | 13, 16 | 1d | 25-11-21 | 25-11-21 | 0d | 0d |
| 20 | Cure slab | 18 | 6d | 26-11-21 | 01-12-21 | 0d | 0d |
| 22 | Erect ext. wall panels [4C] | 20, 08 | 2d | 02-12-21 | 03-12-21 | 0d | 0d |
| 24 | Erect doors [2C] | 07, 22 | 1d | 04-12-21 | 04-12-21 | 0d | 0d |
| 25 | Waterproof & insulate joints [2L] | 22 | 1d | 04-12-21 | 04-12-21 | 0d | 0d |
| 27 | Paint ext. walls [SUB] | 24, 25 | 2d | 05-12-21 | 06-12-21 | 0d | 0d |
| 30 | Cleanup [4L] | 27, 28, 29 | 2d | 07-12-21 | 08-12-21 | 0d | 0d |
| 03 | Fabricate interior wall partition [4C] | 02 | 2d | 05-11-21 | 06-11-21 | 15d | 19d |
| 04 | Fasten wood strips to purlins [2C] | 02 | 2d | 07-11-21 | 08-11-21 | 8d | 13d |
| 05 | Fabricate timber trusses [4C] | 02 | 4d | 09-11-21 | 12-11-21 | 4d | 9d |
| 07 | Fabricate exterior doors [2C] | 02 | 2d | 07-11-21 | 08-11-21 | 17d | 17d |
| 08 | Const. plywood ext. wall panel [4C] | 02 | 3d | 13-11-21 | 15-11-21 | 14d | 14d |
| 10 | Place drain pipes [SUB] | 06 | 1d | 06-11-21 | 06-11-21 | 5d | 5d |
| 13 | Erect steel cols & vert brace [4I] | 12B | 1d | 22-11-21 | 22-11-21 | 0d | 2d |
| 15 | Erect trusses [4I] | 13, 05 | 1d | 23-11-21 | 23-11-21 | 0d | 5d |
| 17 | Fab & erect frames @ truss pans [2C,2I] | 15 | 1d | 25-11-21 | 25-11-21 | 0d | 5d |
| 19 | Erect steel purlins [4I] | 04, 17 | 1d | 26-11-21 | 26-11-21 | 0d | 5d |
| 21 | Place red bridging & weld [4I] | 19 | 1d | 27-11-21 | 27-11-21 | 0d | 5d |
| 23 | Nail planks to purlins [2C] | 21 | 2d | 28-11-21 | 29-11-21 | 0d | 5d |
| 26 | Lay tar paper on planks [2L] | 23 | 1d | 30-11-21 | 30-11-21 | 0d | 5d |
| 28 | Erect corrugated roofing [2C] | 26 | 2d | 04-12-21 | 05-12-21 | 5d | 5d |
| 29 | Erect interior wall partitions [4C] | 03, 20, 26 | 1d | 06-12-21 | 06-12-21 | 4d | 4d |




| Activity ID | Activity Name | Start | Finish | Remaining Units |
|---|---|---|---|---|
| **Total** | | 05-11-21 | 08-12-21 | |
| Resource ID Name: C | Carpenters | 05-11-21 | 06-12-21 | |
| Resource ID Name: I | Ironworkers | 16-11-21 | 27-11-21 | |
| Resource ID Name: L | Laborers | 05-11-21 | 08-12-21 | |

| 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 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Total** | | | | | 8 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 8 | 3 | | | | 1 | 6 | 6 | 6 | 7 | 4 | 4 | 2 | 2 | 2 | | 4 | 4 | 6 | 2 | 4 | 4 | 4 | | | | | |
| Resource ID Name: C | | | | | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 1 | | | | | | | 4 | 3 | | | 2 | 2 | | | 4 | 4 | 4 | 2 | 4 | | | | | | | |
| Resource ID Name: I | | | | | | | | | | | | | | | | 2 | | | | | | 4 | 4 | 2 | 2 | 4 | 4 | | | | | | | | | | | | | | | | |
| Resource ID Name: L | | | | | 4 | | | | | | | | | | | 2 | 2 | | | | 1 | 2 | 2 | | 2 | | | | | 2 | | | | 2 | | | 4 | 4 | | | | | |

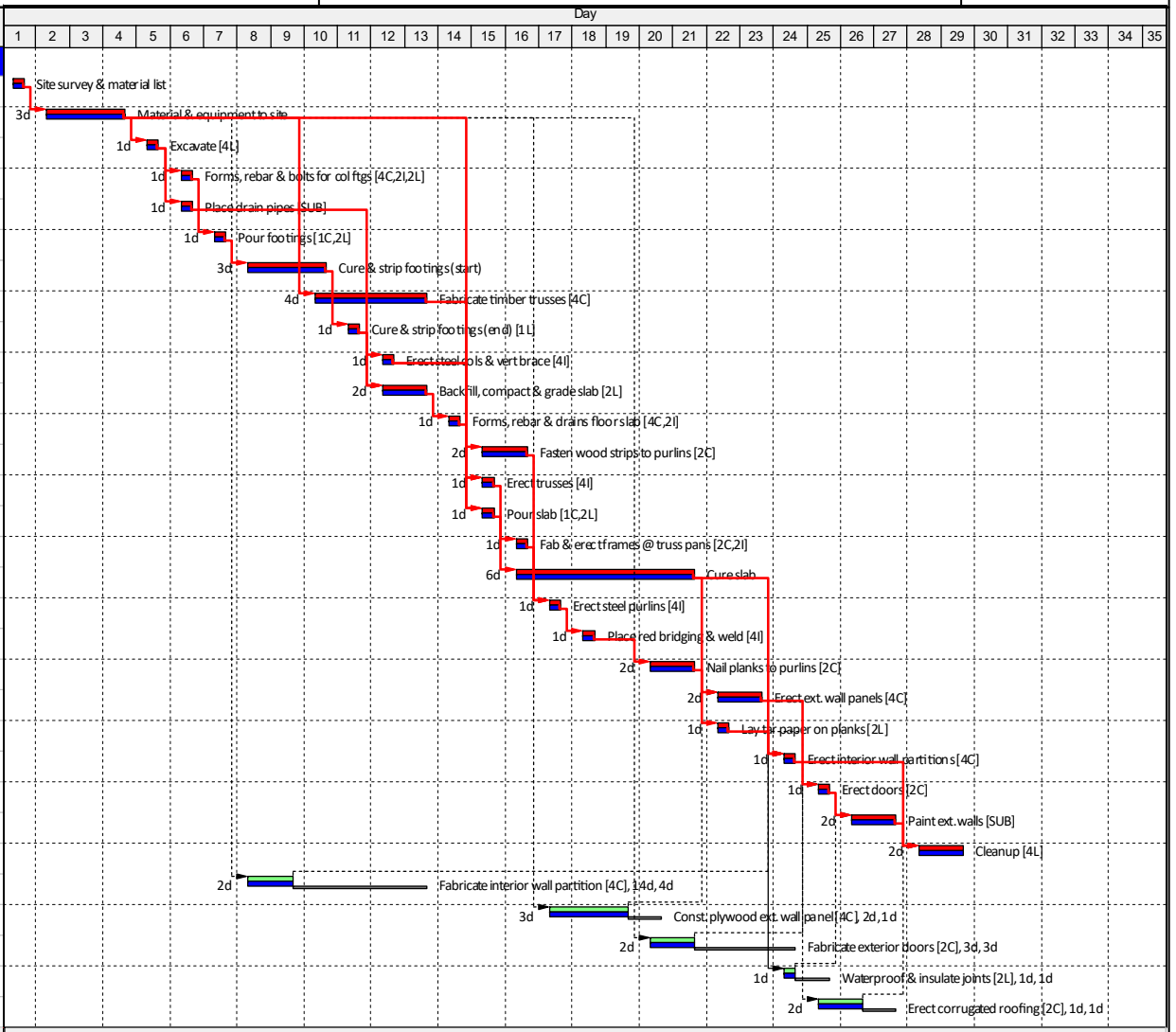
Critical Rem Work
Remaining Work
Early Bar
Float Bar

| Date | Revision | Checked | Approved |
|---|---|---|---|
| 8-12-21 | Default leveling by P6, No splits, T=38d | PGI | PGI |
| | Preserve schedule early and late dates: YES | | |
| | Sorted by: Critical, Early Start, Activity ID | | |

Course: CEE538
User: P.G. Ioannou

| Primavera P6 Professional R20.12 | Project: Warehouse-No Splits-TF-Leveling-T=29d | Layout: 2021F-Lab6.2-TF Leveling-No Splits | Date: 14-11-21 |
|---|---|---|---|

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




| Activity ID | Activity Name | Start | Finish | Remaining 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** | | 05-11-21 | 29-11-21 | | | | | | 4 | 8 | 3 | 4 | 4 | 4 | 5 | 10 | 6 | 6 | 9 | 6 | 8 | 8 | 4 | 4 | 4 | 6 | 4 | 6 | 4 | 2 | | 4 | 4 | | | | | | | |
| Resource ID Name: WARE - Root | | 05-11-21 | 29-11-21 | | | | | | 4 | 8 | 3 | 4 | 4 | 4 | 5 | 10 | 6 | 6 | 9 | 6 | 8 | 8 | 4 | 4 | 4 | 6 | 4 | 6 | 4 | 2 | | 4 | 4 | | | | | | | |
| Resource ID Name: C Carpenter | | 06-11-21 | 26-11-21 | | | | | | | 4 | 1 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 3 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 2 | | | | | | | | | | |
| Resource ID Name: I Ironworkers | | 06-11-21 | 18-11-21 | | | | | | | 2 | | | | | | 4 | | 2 | 4 | 2 | 4 | 4 | | | | | | | | | | | | | | | | | |
| Resource ID Name: L Laborers | | 05-11-21 | 29-11-21 | | | | | | 4 | 2 | 2 | | | | 1 | 2 | 2 | | 2 | | | | | | | 2 | | 2 | | | | 4 | 4 | | | | | | |

Critical Rem Work
Float Bar
Remaining Work
Early Bar

| Date | Revision | Checked | Approved |
|---|---|---|---|
| 14-11-21 | Repeated TF-leveling by P6, No splits, T=29d | PGI | PGI |
| | Preserve schedule early and late dates: No | | |
| | Sorted by: Critical, Early Start, Activity ID | | |

Course: CEE538
User: P.G. Ioannou

**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 (3d) | 12A (3d) | 0 | C | - | - | - | C |
| 31 (1d) | 12B (1d) | 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 |

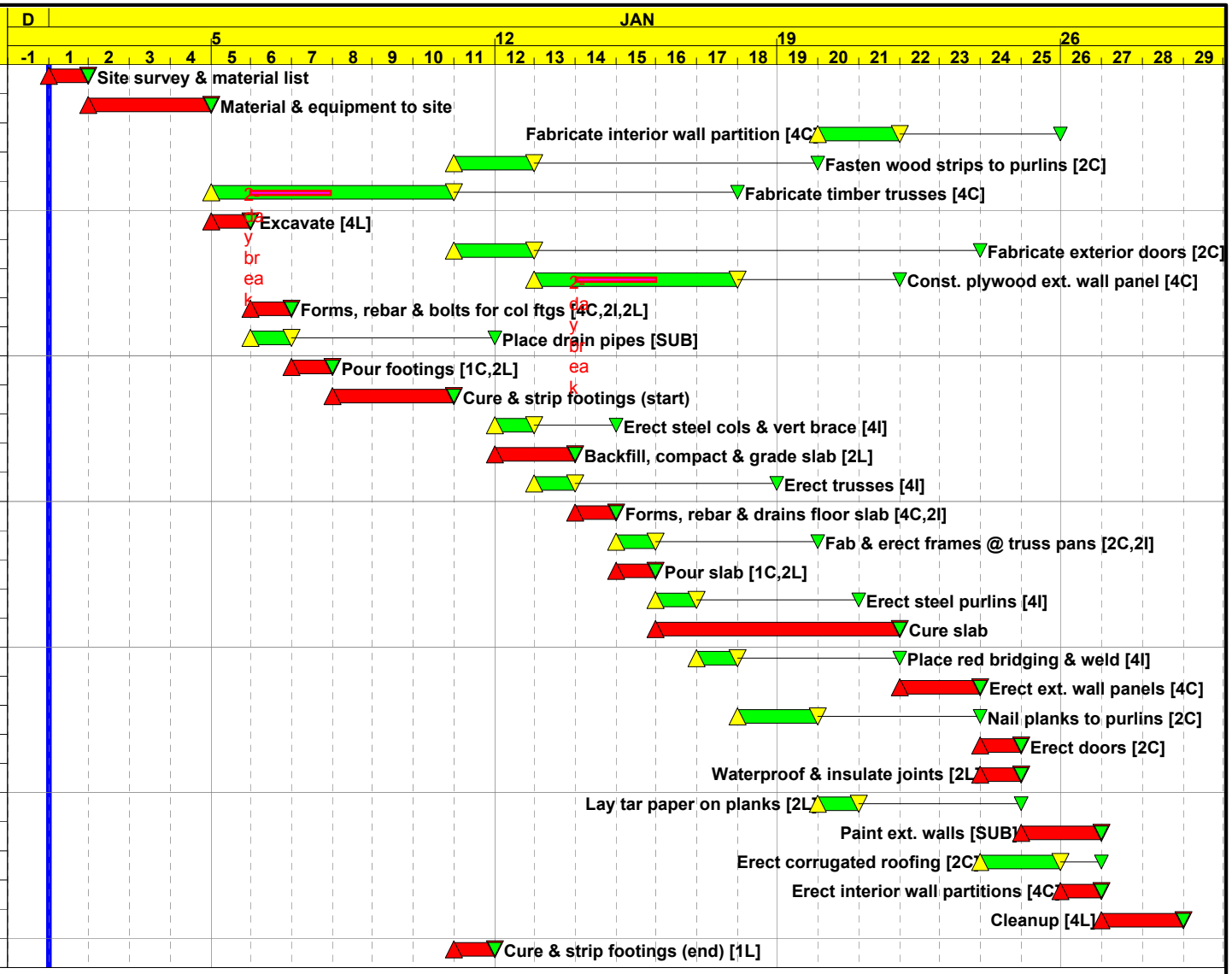
[1] Table 2 is a revised version of Table 1 from the paper:
Fondahl, J. (1991). "*The Development of the Construction Engineer: Past Progress and Future Problems*" J. Constr. Eng. Mgmt., ASCE, Vol 117, No 3, pp 380-392.

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) |
| **12** (4d) | = | **12** (3d) + **31** (1d) | **12A** (3d) + **12B** (1d) |

This enables MS Project and P6 (neither of which can split activities automatically when leveling resources) to "split" into two activities each of the three activities 5, 8, and 12, as described by Fondahl (1991).

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




| Row | Group Name | 31 | 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Carpenters | | | | | | 4 | 4 | 1 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 3 | 4 | 4 | 2 | 2 | 4 | 4 | 4 | 4 | 4 | 2 | 4 | | | |
| 2 | Ironworkers | | | | | | | 2 | | | | | | 4 | 4 | 2 | 2 | 4 | 4 | | | | | | | | | | | | |
| 3 | Laborers | | | | | | 4 | 2 | 2 | | | | 1 | 2 | 2 | | 2 | | | | | 2 | | | | 2 | | | 4 | 4 | |

D 1997 — JAN 1998

Start Date 01JAN98
Finish Date 28JAN98
Data Date 01JAN98
Run Date 19JUN03 15:50

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Early Bar
Float Bar
Progress Bar
Critical Activity

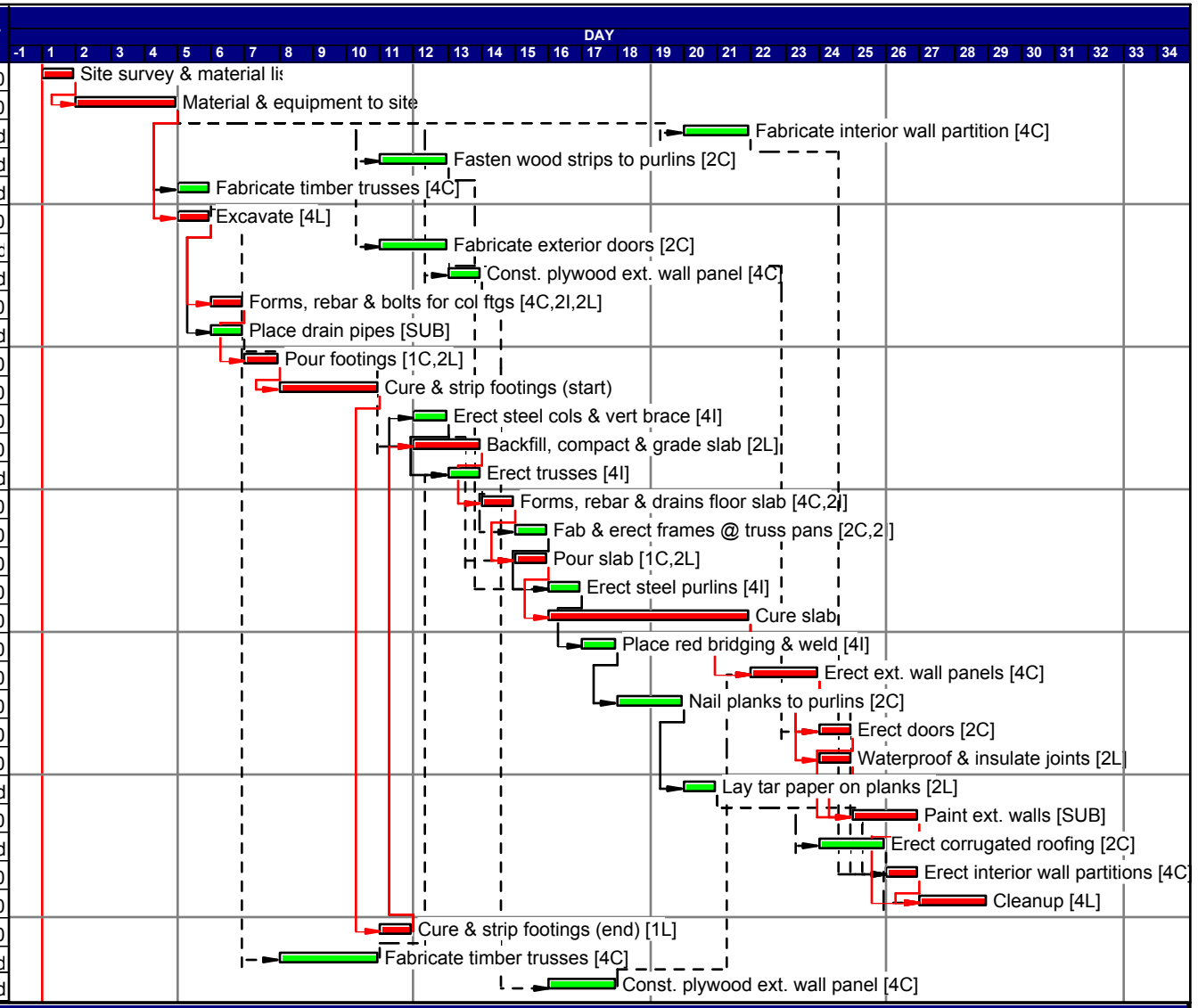
WARE Sheet 1 of 1

Warehouse Project (Before Change Order)
Leveled by P3, With Splits: T=28 days
Act5=6d(1W,2B,3W); Act8=5d(1W,2B,2W)

P3 splits Act 8 differently from Fondahl's paper:
P3 : 3 days = 1day + 2 days
Fondahl: 3 days = 2 days + 1 day

Thus, the TF for Act. 4 to 8B shown in Fondahl's paper are different from those in P3: "Alternate Optimum"

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




| ID | Description | Units | Display: Quantity |
|---|---|---|---|
| C | Carpenters | CA | 4 4 1 4 4 4 4 4 4 4 3 4 4 2 2 4 4 4 4 4 2 4 |
| I | Ironworkers | IW | 2 4 4 2 2 4 4 |
| L | Laborers | LB | 4 2 2 1 2 2 2 2 4 4 |

-1 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
DAY

| | |
|---|---|
| Start date | 01JAN98 |
| Finish date | 28JAN98 |
| Data date | 01JAN98 |
| Run date | 19JUN03 |
| Page number | 1A |
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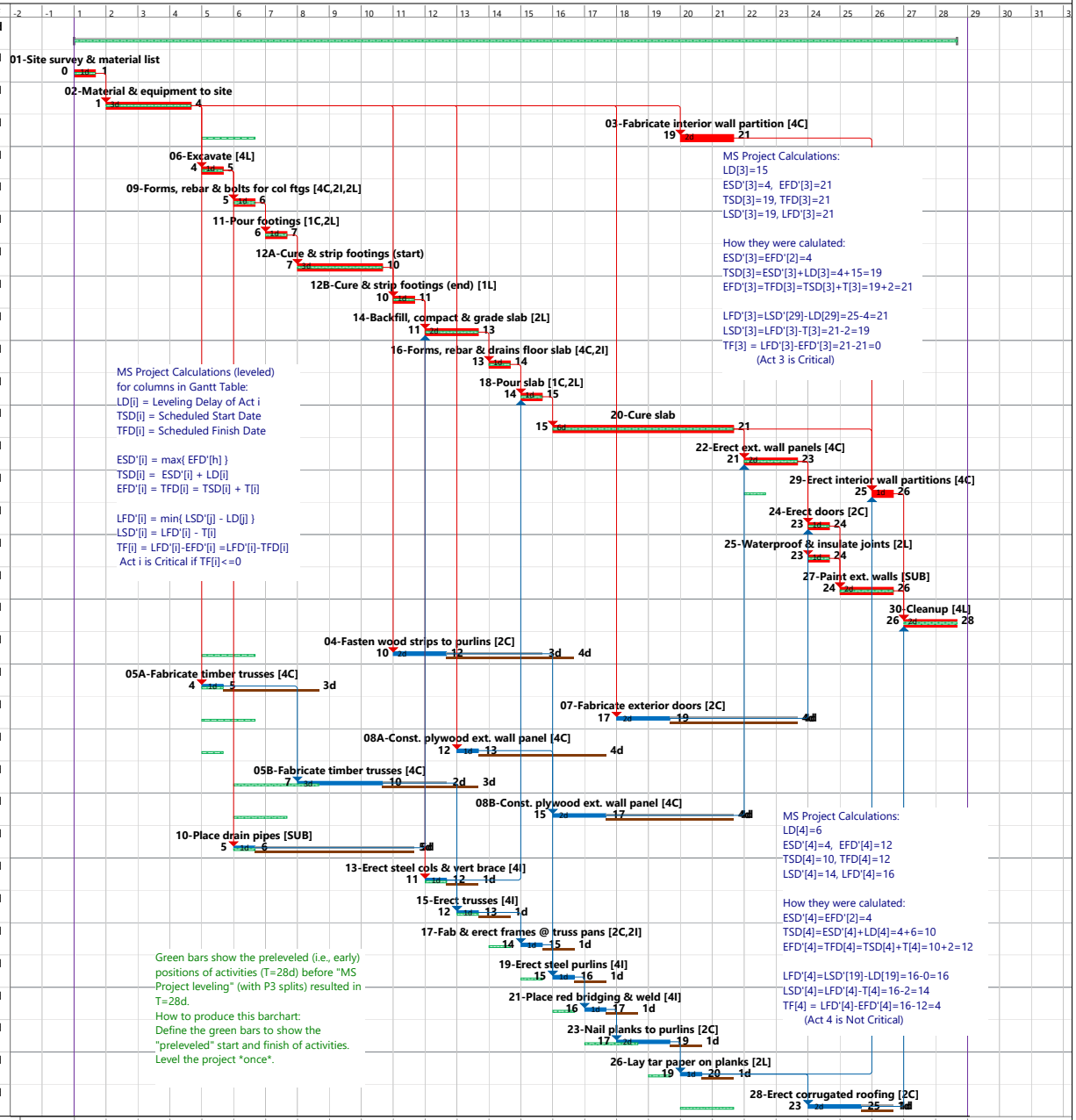
Warehouse Project (Before C.O.)
Levelled by SureTrak with P3 Splits for Act 8: T=28d
T5 = 1 + 3 = 4d, T8 = 1 + 2 = 3d

P3 splits Act 8 differently from Fondahl's paper:
P3 : T8 = 1 + 2 = 3 days
Fondahl: T8 = 2 + 1 = 3 days
Hence, TF are different: "Alternate Optimum"

Early bar
Progress bar
Critical bar
Summary bar
Start milestone point
Finish milestone poin

MS Project Pro | Project: Warehouse Project | Date: 11/15/21

| ID | Act | Pred | T | Lev | ESD | TSD | LSD | EFD | TFD | 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 | 15ed | 4 | 19 | 19 | 21 | 21 | 21 | 0d | 0d |
| 6 | 06-Excavate [4L] | 2 | 1d | 0ed | 4 | 4 | 4 | 5 | 5 | 5 | 0d | 0d |
| 9 | 09-Forms, rebar & bolts for col ftgs [4C,2I,2L] | 6 | 1d | 0ed | 5 | 5 | 5 | 6 | 6 | 6 | 0d | 0d |
| 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 |
| 14 | 14-Backfill, compact & grade slab [2L] | 10,31 | 2d | 0ed | 11 | 11 | 11 | 13 | 13 | 13 | 0d | 0d |
| 16 | 16-Forms, rebar & drains floor slab [4C,2I] | 14 | 1d | 0ed | 13 | 13 | 13 | 14 | 14 | 14 | 0d | 0d |
| 18 | 18-Pour slab [1C,2L] | 13,16 | 1d | 0ed | 14 | 14 | 14 | 15 | 15 | 15 | 0d | 0d |
| 20 | 20-Cure slab | 18 | 6d | 0ed | 15 | 15 | 15 | 21 | 21 | 21 | 0d | 0d |
| 22 | 22-Erect ext. wall panels [4C] | 20,33 | 2d | 0ed | 21 | 21 | 21 | 23 | 23 | 23 | 0d | 0d |
| 29 | 29-Erect interior wall partitions [4C] | 3,20,26 | 1d | 4ed | 21 | 25 | 25 | 26 | 26 | 26 | 0d | 0d |
| 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 | 26 | 26 | 28 | 28 | 28 | 0d | 0d |
| 4 | 04-Fasten wood strips to purlins [2C] | 2 | 2d | 6ed | 4 | 10 | 14 | 12 | 12 | 16 | 3d | 4d |
| 5 | 05A-Fabricate timber trusses [4C] | 2 | 1d | 0ed | 4 | 4 | 7 | 5 | 5 | 8 | 0d | 3d |
| 7 | 07-Fabricate exterior doors [2C] | 2 | 2d | 13ed | 4 | 17 | 21 | 19 | 19 | 23 | 4d | 4d |
| 8 | 08A-Const. plywood ext. wall panel [4C] | 2 | 1d | 8ed | 4 | 12 | 16 | 13 | 13 | 17 | 0d | 4d |
| 32 | 05B-Fabricate timber trusses [4C] | 5 | 3d | 2ed | 5 | 7 | 10 | 10 | 10 | 13 | 2d | 3d |
| 33 | 08B-Const. plywood ext. wall panel [4C] | 8 | 2d | 2ed | 13 | 15 | 19 | 17 | 17 | 21 | 4d | 4d |
| 10 | 10-Place drain pipes [SUB] | 6 | 1d | 0ed | 5 | 5 | 10 | 6 | 6 | 11 | 5d | 5d |
| 13 | 13-Erect steel cols & vert brace [4I] | 31 | 1d | 0ed | 11 | 11 | 12 | 12 | 12 | 13 | 0d | 1d |
| 15 | 15-Erect trusses [4I] | 13,32 | 1d | 0ed | 12 | 12 | 13 | 13 | 13 | 14 | 0d | 1d |
| 17 | 17-Fab & erect frames @ truss pans [2C,2I] | 15 | 1d | 1ed | 13 | 14 | 15 | 15 | 15 | 16 | 0d | 1d |
| 19 | 19-Erect steel purlins [4I] | 4,17 | 1d | 0ed | 15 | 15 | 16 | 16 | 16 | 17 | 0d | 1d |
| 21 | 21-Place red bridging & weld [4I] | 19 | 1d | 0ed | 16 | 16 | 17 | 17 | 17 | 18 | 0d | 1d |
| 23 | 23-Nail planks to purlins [2C] | 21 | 2d | 0ed | 17 | 17 | 18 | 19 | 19 | 20 | 0d | 1d |
| 26 | 26-Lay tar paper on planks [2L] | 23 | 1d | 0ed | 19 | 19 | 20 | 20 | 20 | 21 | 0d | 1d |
| 28 | 28-Erect corrugated roofing [2C] | 26 | 2d | 3ed | 20 | 23 | 24 | 25 | 25 | 26 | 1d | 1d |




MS Project Calculations:
LD[3]=15
ESD'[3]=4, EFD'[3]=21
TSD[3]=19, TFD[3]=21
LSD'[3]=19, LFD'[3]=21

How they were calulated:
ESD'[3]=EFD'[2]=4
TSD[3]=ESD'[3]+LD[3]=4+15=19
EFD'[3]=TFD[3]=TSD[3]+T[3]=19+2=21

LFD'[3]=LSD'[29]-LD[29]=25-4=21
LSD'[3]=LFD'[3]-T[3]=21-2=19
TF[3] = LFD'[3]-EFD'[3]=21-21=0
(Act 3 is 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

MS Project Calculations:
LD[4]=6
ESD'[4]=4, EFD'[4]=12
TSD[4]=10, TFD[4]=12
LSD'[4]=14, LFD'[4]=16

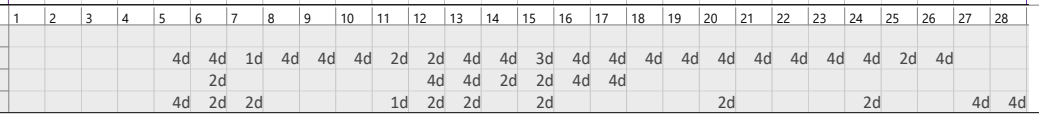
How they were calulated:
ESD'[4]=EFD'[2]=4
TSD[4]=ESD'[4]+LD[4]=4+6=10
EFD'[4]=TFD[4]=TSD[4]+T[4]=10+2=12

LFD'[4]=LSD'[19]-LD[19]=16-0=16
LSD'[4]=LFD'[4]-T[4]=16-2=14
TF[4] = LFD'[4]-EFD'[4]=16-12=4
(Act 4 is Not Critical)

Green bars show the preleveled (i.e., early) positions of activities (T=28d) before "MS Project leveling" (with P3 splits) resulted in T=28d.
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 |
| 3 | Ironworkers | 22d | Work |
| 2 | Laborers | 27d | Work |



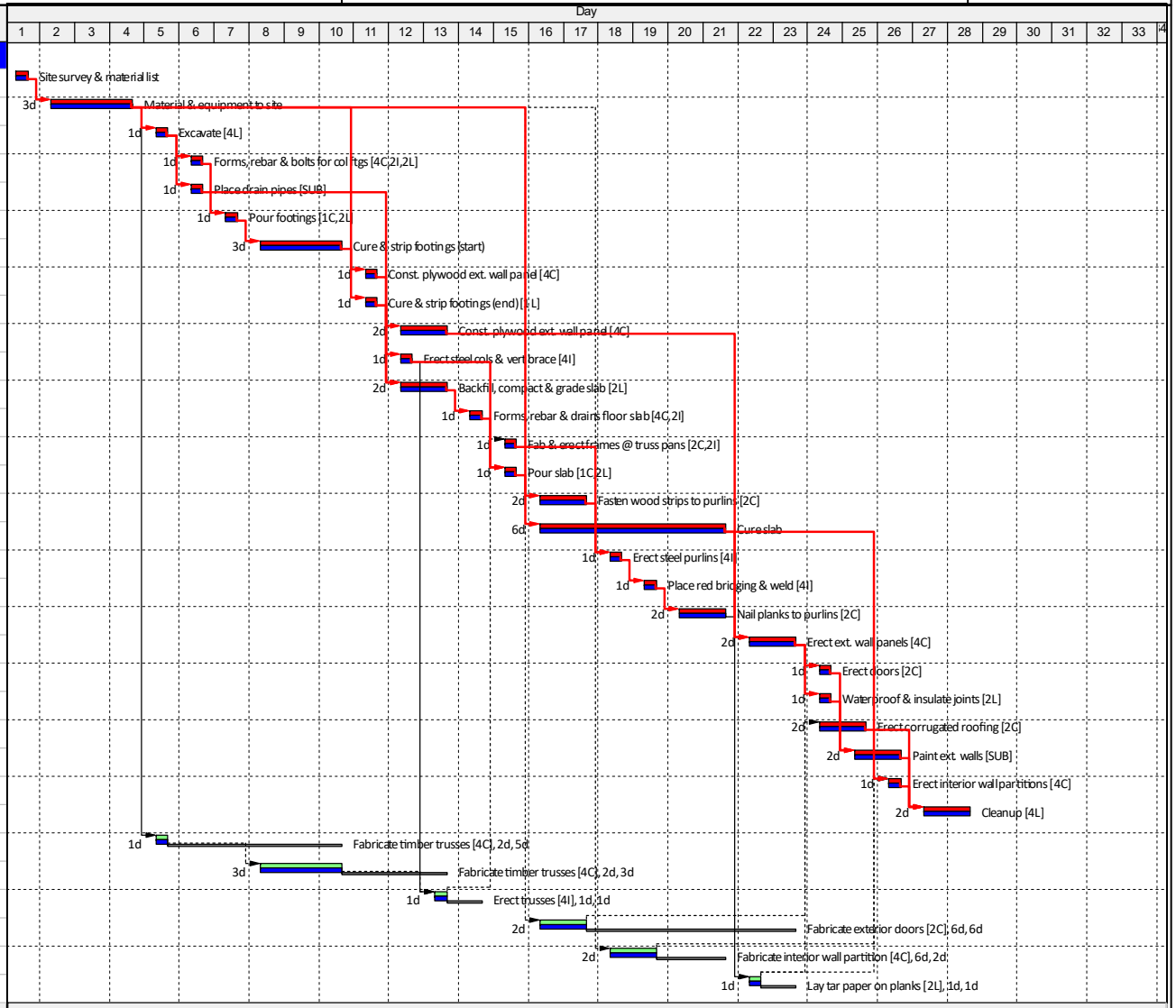

_Lab6 Gantt Chart - P3 Splits
Sorted by: Critical, Preleved Start, Name

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 R20.12 | Project: Warehouse-P3 Splits-TF-leveling-T=28d | Layout: 2021F-Lab6.3-TF Leveling-P3 Splits | Date: 14-11-21 |
|---|---|---|---|

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




| Activity ID | Activity Name | Start | Finish | Remaining 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Total** | | 05-11-21 | 28-11-21 | | | | | | 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: WARE - Root Resour | | 05-11-21 | 28-11-21 | | | | | | 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 | | 05-11-21 | 26-11-21 | | | | | | 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 | | 06-11-21 | 19-11-21 | | | | | | | 2 | | | | | | 4 | 4 | 2 | 2 | | | 4 | 4 | | | | | | | | | | | | | | |
| Resource ID Name: L Laborers | | 05-11-21 | 28-11-21 | | | | | | 4 | 2 | 2 | | | | 1 | 2 | 2 | | 2 | | | | | | | 2 | | 2 | | | 4 | 4 | | | | | |

Critical Rem Work
Remaining Work
Early Bar
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: Critical, Early Start, Activity ID

Course: CEE538
User: P.G. Ioannou

## 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.

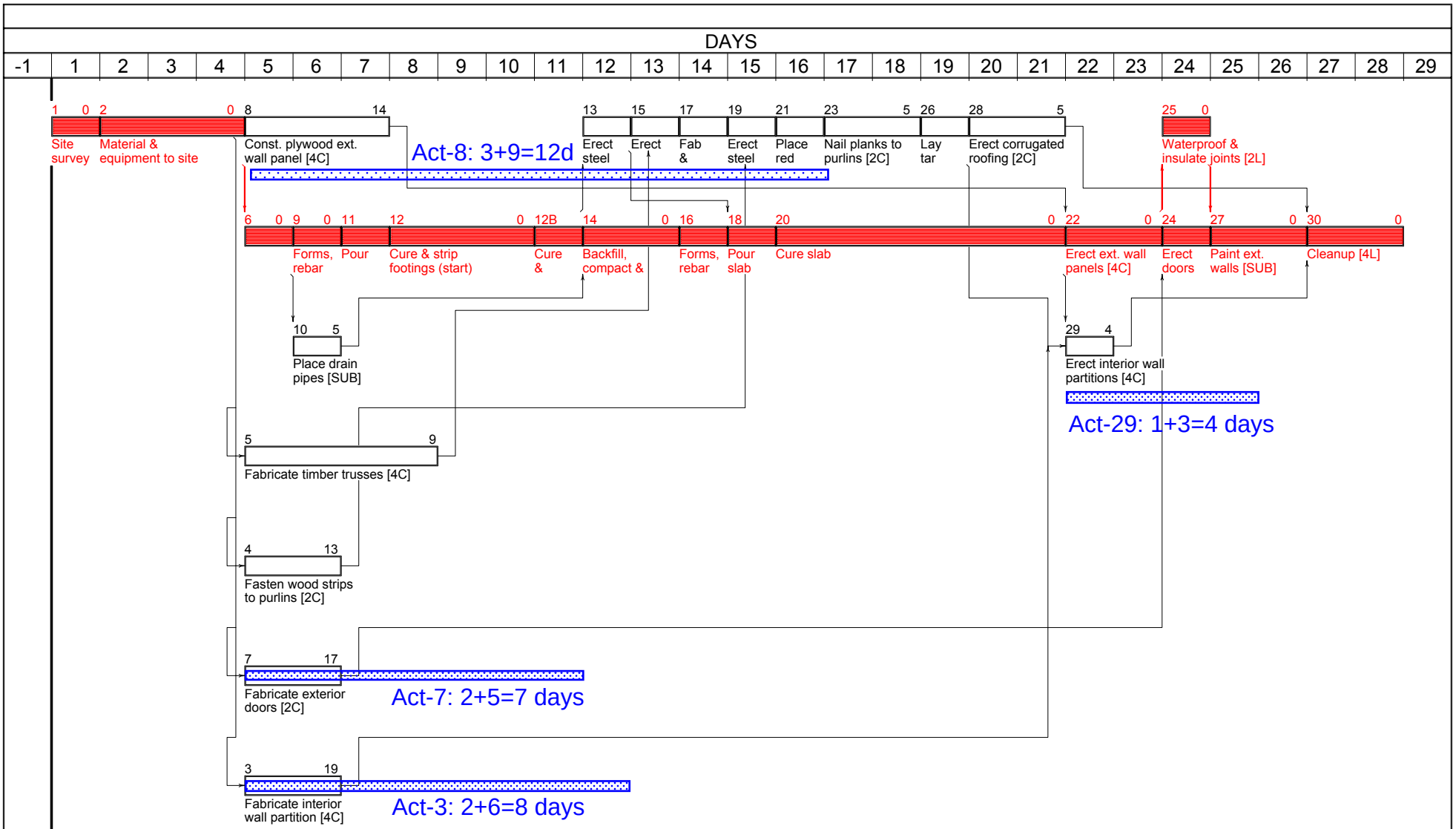
- How much time extension should you claim? Document your claim by producing a schedule using the revised activity duration estimates and subject to the above resource availability constraints. Knowing that this schedule will be challenged by the owner's top engineering talent, you must develop the shortest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




| | |
|---|---|
| Plot Date | 19JUN03 |
| Data Date | 1JAN98 |
| Project Start | 1JAN98 |
| Project Finish | 28JAN98 |

(c) Primavera Systems, Inc.

act id — inactive — tf

Activity Bar/Early Dates
Critical Activity
Progress Bar
Milestone/Flag Activity

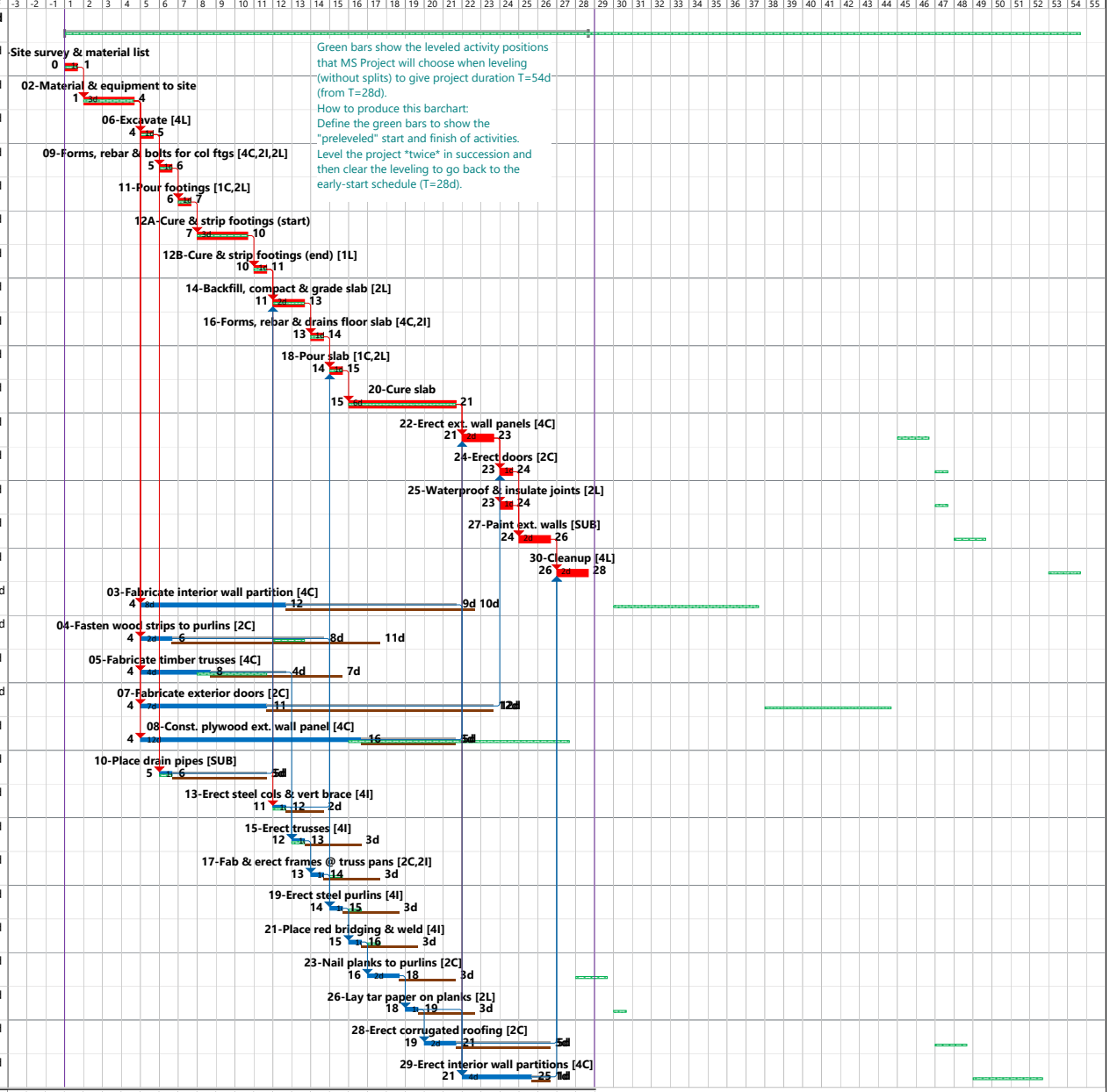
Sheet 1 of 1

# P3 Time-Scaled Precedence Network
## Duration: T = 28 days
## Warehouse Project (Fondahl)

Early Start Schedule

| Date | Revision | Checked | Approved |
|---|---|---|---|
| | | | |
| | | | |
| | | | |
| | | | |

| ID | Act | Pred | T | Lev | ESD | TSD | LSD | EFD | TFD | 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 |
| 6 | 06-Excavate [4L] | 2 | 1d | 0ed | 4 | 4 | 4 | 5 | 5 | 5 | 0d | 0d |
| 9 | 09-Forms, rebar & bolts for col ftgs [4C,2I,2L] | 6 | 1d | 0ed | 5 | 5 | 5 | 6 | 6 | 6 | 0d | 0d |
| 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 |
| 14 | 14-Backfill, compact & grade slab [2L] | 10,31 | 2d | 0ed | 11 | 11 | 11 | 13 | 13 | 13 | 0d | 0d |
| 16 | 16-Forms, rebar & drains floor slab [4C,2I] | 14 | 1d | 0ed | 13 | 13 | 13 | 14 | 14 | 14 | 0d | 0d |
| 18 | 18-Pour slab [1C,2L] | 13,16 | 1d | 0ed | 14 | 14 | 14 | 15 | 15 | 15 | 0d | 0d |
| 20 | 20-Cure slab | 18 | 6d | 0ed | 15 | 15 | 15 | 21 | 21 | 21 | 0d | 0d |
| 22 | 22-Erect ext. wall panels [4C] | 20,8 | 2d | 0ed | 21 | 21 | 21 | 23 | 23 | 23 | 0d | 0d |
| 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 | 26 | 26 | 28 | 28 | 28 | 0d | 0d |
| 3 | 03-Fabricate interior wall partition [4C] | 2 | 8d | 0ed | 4 | 4 | 14 | 12 | 12 | 22 | 9d | 10d |
| 4 | 04-Fasten wood strips to purlins [2C] | 2 | 2d | 0ed | 4 | 4 | 15 | 6 | 6 | 17 | 8d | 11d |
| 5 | 05-Fabricate timber trusses [4C] | 2 | 4d | 0ed | 4 | 4 | 11 | 8 | 8 | 15 | 4d | 7d |
| 7 | 07-Fabricate exterior doors [2C] | 2 | 7d | 0ed | 4 | 4 | 16 | 11 | 11 | 23 | 12d | 12d |
| 8 | 08-Const. plywood ext. wall panel [4C] | 2 | 12d | 0ed | 4 | 4 | 9 | 16 | 16 | 21 | 5d | 5d |
| 10 | 10-Place drain pipes [SUB] | 6 | 1d | 0ed | 5 | 5 | 10 | 6 | 6 | 11 | 5d | 5d |
| 13 | 13-Erect steel cols & vert brace [4I] | 31 | 1d | 0ed | 11 | 11 | 13 | 12 | 12 | 14 | 0d | 2d |
| 15 | 15-Erect trusses [4I] | 13,5 | 1d | 0ed | 12 | 12 | 15 | 13 | 13 | 16 | 0d | 3d |
| 17 | 17-Fab & erect frames @ truss pans [2C,2I] | 15 | 1d | 0ed | 13 | 13 | 16 | 14 | 14 | 17 | 0d | 3d |
| 19 | 19-Erect steel purlins [4I] | 4,17 | 1d | 0ed | 14 | 14 | 17 | 15 | 15 | 18 | 0d | 3d |
| 21 | 21-Place red bridging & weld [4I] | 19 | 1d | 0ed | 15 | 15 | 18 | 16 | 16 | 19 | 0d | 3d |
| 23 | 23-Nail planks to purlins [2C] | 21 | 2d | 0ed | 16 | 16 | 19 | 18 | 18 | 21 | 0d | 3d |
| 26 | 26-Lay tar paper on planks [2L] | 23 | 1d | 0ed | 18 | 18 | 21 | 19 | 19 | 22 | 0d | 3d |
| 28 | 28-Erect corrugated roofing [2C] | 26 | 2d | 0ed | 19 | 19 | 24 | 21 | 21 | 26 | 5d | 5d |
| 29 | 29-Erect interior wall partitions [4C] | 3,20,26 | 4d | 0ed | 21 | 21 | 22 | 25 | 25 | 26 | 1d | 1d |

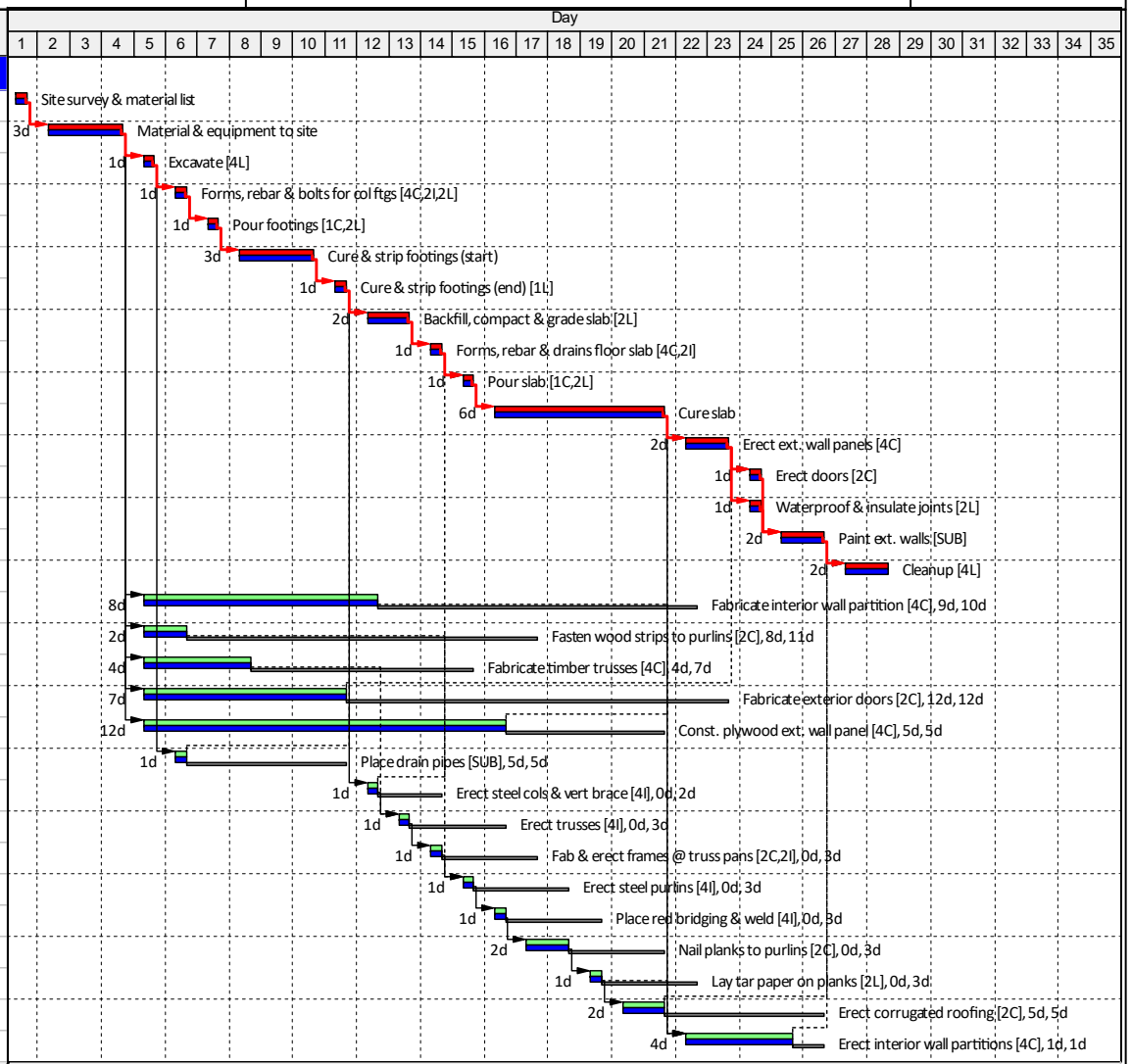



Note: The Resource Usage spreadsheet, shown on the right, was printed to pdf separately and was pasted to the pdf for the Gantt Chart using "Bluebeam Revu".
If you find this too difficult, you can print and submit the two reports separately.

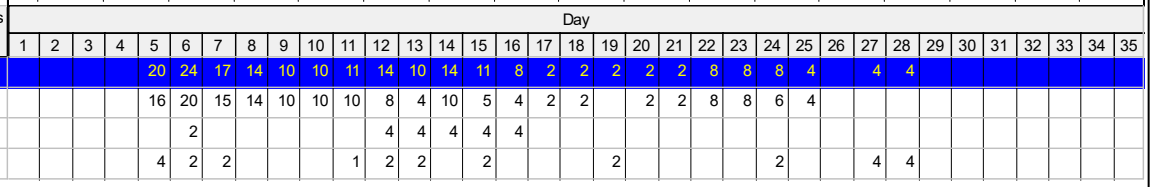
| ID | Resource Name | Work | Details |
|---|---|---|---|
| | Unassigned | 0d | Work |
| 1 | Carpenters | 160d | Work |
| 2 | Ironworkers | 22d | Work |
| 3 | Laborers | 27d | Work |

| Primavera P6 Professional R20.12 | Project: WH-After CO-Unleveled-T=28d | Layout: 2021F-Lab6.4-CO-Unleveled | Date: 01-12-21 |
|---|---|---|---|

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




| Activity ID | Remaining Units | Remaining Units |
|---|---|---|
| **Total** | 209 | |
| Resource ID Name: C Carpenters | 160 | |
| Resource ID Name: I Ironworkers | 22 | |
| Resource ID Name: L Laborers | 27 | |

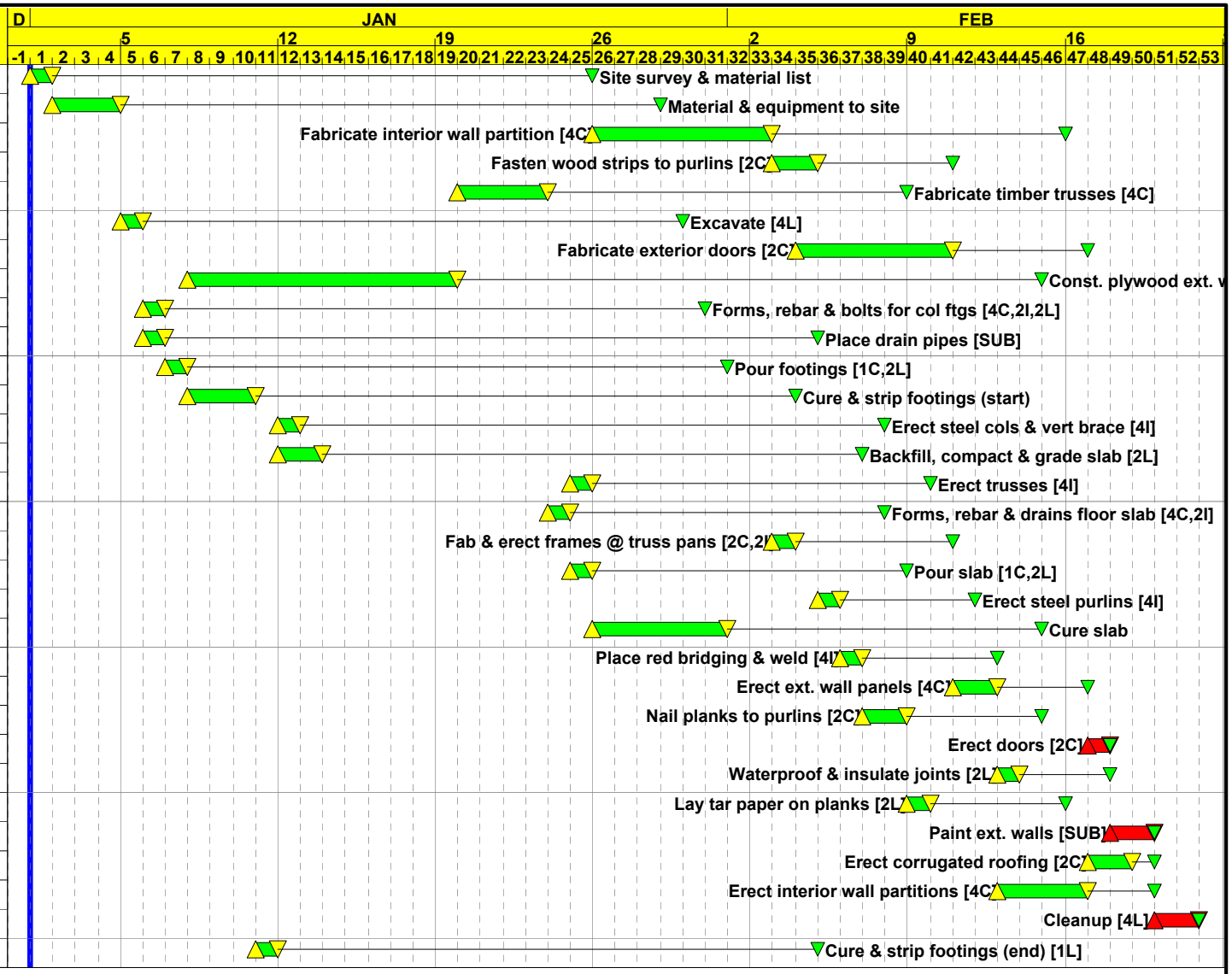



Critical Rem Work
Remaining Work
Early Bar
Float Bar

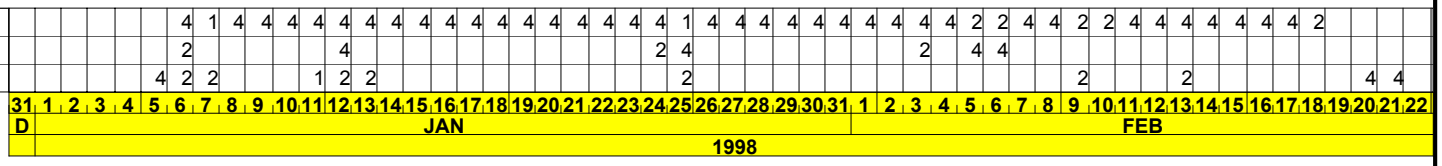
| Date | Revision | Check... | Approved |
|---|---|---|---|
| 11-18-21 | After Change Order - Early-Start Schedule, Unleveled, T=28d | PGI | PGI |
| | (To print all 3 res rows in sprdsht, select them on screen) | | |
| | Sorted by: Critical, Start, Activity ID | | |

Course: CEE538
User: P.G. Ioannou

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




| Row | Group Name |
|---|---|
| 1 | Carpenters |
| 2 | Ironworkers |
| 3 | Laborers |




Start Date 01JAN98
Finish Date 21FEB98
Data Date 01JAN98
Run Date 19JUN03 16:11

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Early Bar
Float Bar
Progress Bar
Critical Activity

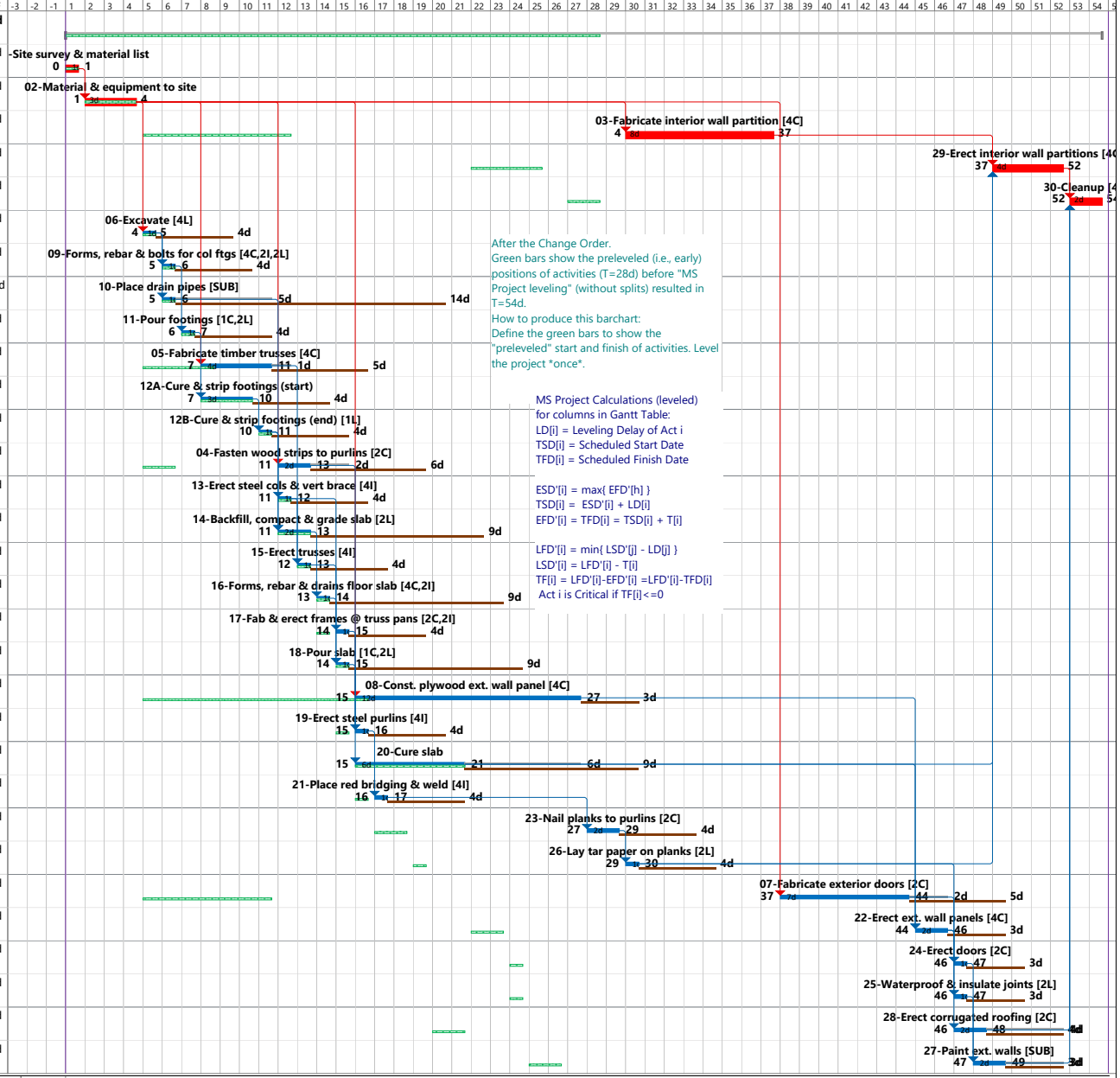
WARE Sheet 1 of 1

Warehouse Project (After Change Order)
Levelled by P3, No Splits: T=52d
T3=2+6=8, T7=2+5=7, T8=3+9=12, T29=1+3=4

Project Duration = 52 days
Same as found by Fondahl using P3 and no splits

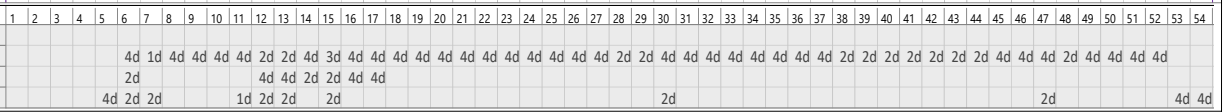
MS Project Pro | Project: Warehouse Project | Date: 12/1/21

| ID | Act | Pred | T | Lev | ESD | TSD | LSD | EFD | TFD | LFD | FF | TF |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | **Warehouse Project** | | **54d** | **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 | 8d | 25ed | 4 | 29 | 29 | 37 | 37 | 37 | 0d | 0d |
| 29 | 29-Erect interior wall partitions [4C] | 3,20,26 | 4d | 11ed | 37 | 48 | 48 | 52 | 52 | 52 | 0d | 0d |
| 30 | 30-Cleanup [4L] | 27,28,29 | 2d | 0ed | 52 | 52 | 52 | 54 | 54 | 54 | 0d | 0d |
| 6 | 06-Excavate [4L] | 2 | 1d | 0ed | 4 | 4 | 8 | 5 | 5 | 9 | 0d | 4d |
| 9 | 09-Forms, rebar & bolts for col ftgs [4C,2I,2L] | 6 | 1d | 0ed | 5 | 5 | 9 | 6 | 6 | 10 | 0d | 4d |
| 10 | 10-Place drain pipes [SUB] | 6 | 1d | 0ed | 5 | 5 | 19 | 6 | 6 | 20 | 5d | 14d |
| 11 | 11-Pour footings [1C,2L] | 9 | 1d | 0ed | 6 | 6 | 10 | 7 | 7 | 11 | 0d | 4d |
| 5 | 05-Fabricate timber trusses [4C] | 2 | 4d | 3ed | 4 | 7 | 12 | 11 | 11 | 16 | 1d | 5d |
| 12 | 12A-Cure & strip footings (start) | 11 | 3d | 0ed | 7 | 7 | 11 | 10 | 10 | 14 | 0d | 4d |
| 31 | 12B-Cure & strip footings (end) [1L] | 12 | 1d | 0ed | 10 | 10 | 14 | 11 | 11 | 15 | 0d | 4d |
| 4 | 04-Fasten wood strips to purlins [2C] | 2 | 2d | 7ed | 4 | 11 | 17 | 13 | 13 | 19 | 2d | 6d |
| 13 | 13-Erect steel cols & vert brace [4I] | 31 | 1d | 0ed | 11 | 11 | 15 | 12 | 12 | 16 | 0d | 4d |
| 14 | 14-Backfill, compact & grade slab [2L] | 10,31 | 2d | 0ed | 11 | 11 | 20 | 13 | 13 | 22 | 0d | 9d |
| 15 | 15-Erect trusses [4I] | 13,5 | 1d | 0ed | 12 | 12 | 16 | 13 | 13 | 17 | 0d | 4d |
| 16 | 16-Forms, rebar & drains floor slab [4C,2I] | 14 | 1d | 0ed | 13 | 13 | 22 | 14 | 14 | 23 | 0d | 9d |
| 17 | 17-Fab & erect frames @ truss pans [2C,2I] | 15 | 1d | 1ed | 13 | 14 | 18 | 15 | 15 | 19 | 0d | 4d |
| 18 | 18-Pour slab [1C,2L] | 13,16 | 1d | 0ed | 14 | 14 | 23 | 15 | 15 | 24 | 0d | 9d |
| 8 | 08-Const. plywood ext. wall panel [4C] | 2 | 12d | 11ed | 4 | 15 | 18 | 27 | 27 | 30 | 0d | 3d |
| 19 | 19-Erect steel purlins [4I] | 4,17 | 1d | 0ed | 15 | 15 | 19 | 16 | 16 | 20 | 0d | 4d |
| 20 | 20-Cure slab | 18 | 6d | 0ed | 15 | 15 | 24 | 21 | 21 | 30 | 6d | 9d |
| 21 | 21-Place red bridging & weld [4I] | 19 | 1d | 0ed | 16 | 16 | 20 | 17 | 17 | 21 | 0d | 4d |
| 23 | 23-Nail planks to purlins [2C] | 21 | 2d | 10ed | 17 | 27 | 31 | 29 | 29 | 33 | 0d | 4d |
| 26 | 26-Lay tar paper on planks [2L] | 23 | 1d | 0ed | 29 | 29 | 33 | 30 | 30 | 34 | 0d | 4d |
| 7 | 07-Fabricate exterior doors [2C] | 2 | 7d | 33ed | 4 | 37 | 42 | 44 | 44 | 49 | 2d | 5d |
| 22 | 22-Erect ext. wall panels [4C] | 20,8 | 2d | 17ed | 27 | 44 | 47 | 46 | 46 | 49 | 0d | 3d |
| 24 | 24-Erect doors [2C] | 7,22 | 1d | 0ed | 46 | 46 | 49 | 47 | 47 | 50 | 0d | 3d |
| 25 | 25-Waterproof & insulate joints [2L] | 22 | 1d | 0ed | 46 | 46 | 49 | 47 | 47 | 50 | 0d | 3d |
| 28 | 28-Erect corrugated roofing [2C] | 26 | 2d | 16ed | 30 | 46 | 50 | 48 | 48 | 52 | 4d | 4d |
| 27 | 27-Paint ext. walls [SUB] | 24,25 | 2d | 0ed | 47 | 47 | 50 | 49 | 49 | 52 | 3d | 3d |




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 | 160d | Work |
| 2 | Ironworkers | 22d | Work |
| 3 | Laborers | 27d | Work |



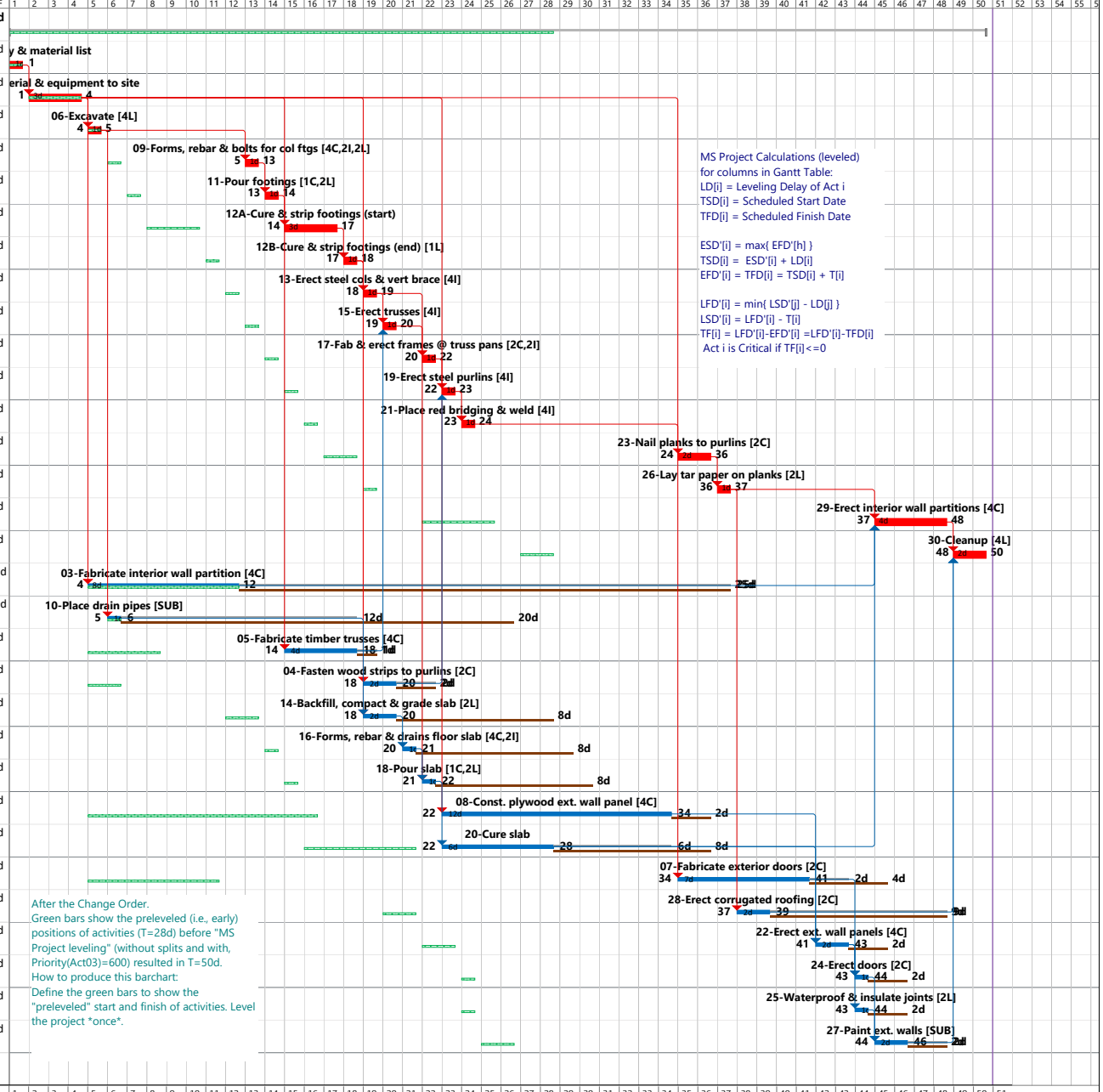

_Lab6 CO Gantt Chart Leveled
Sorted by: Critical, Start, Name

After Change Order --- Leveled by MS Project (default, no splits) --- Project duration T=54d

Course: CEE538
User: P.G. Ioannou

MS Project Pro | Project: Warehouse Project | Date: 12/1/21

| ID | Act | Pred | T | Lev | ESD | TSD | LSD | EFD | TFD | LFD | FF | TF |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | **Warehouse Project** | | **50d** | **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 |
| 6 | 06-Excavate [4L] | 2 | 1d | 0ed | 4 | 4 | 4 | 5 | 5 | 5 | 0d | 0d |
| 9 | 09-Forms, rebar & bolts for col ftgs [4C,2I,2L] | 6 | 1d | 7ed | 5 | 12 | 12 | 13 | 13 | 13 | 0d | 0d |
| 11 | 11-Pour footings [1C,2L] | 9 | 1d | 0ed | 13 | 13 | 13 | 14 | 14 | 14 | 0d | 0d |
| 12 | 12A-Cure & strip footings (start) | 11 | 3d | 0ed | 14 | 14 | 14 | 17 | 17 | 17 | 0d | 0d |
| 31 | 12B-Cure & strip footings (end) [1L] | 12 | 1d | 0ed | 17 | 17 | 17 | 18 | 18 | 18 | 0d | 0d |
| 13 | 13-Erect steel cols & vert brace [4I] | 31 | 1d | 0ed | 18 | 18 | 18 | 19 | 19 | 19 | 0d | 0d |
| 15 | 15-Erect trusses [4I] | 13,5 | 1d | 0ed | 19 | 19 | 19 | 20 | 20 | 20 | 0d | 0d |
| 17 | 17-Fab & erect frames @ truss pans [2C,2I] | 15 | 1d | 1ed | 20 | 21 | 21 | 22 | 22 | 22 | 0d | 0d |
| 19 | 19-Erect steel purlins [4I] | 4,17 | 1d | 0ed | 22 | 22 | 22 | 23 | 23 | 23 | 0d | 0d |
| 21 | 21-Place red bridging & weld [4I] | 19 | 1d | 0ed | 23 | 23 | 23 | 24 | 24 | 24 | 0d | 0d |
| 23 | 23-Nail planks to purlins [2C] | 21 | 2d | 10ed | 24 | 34 | 34 | 36 | 36 | 36 | 0d | 0d |
| 26 | 26-Lay tar paper on planks [2L] | 23 | 1d | 0ed | 36 | 36 | 36 | 37 | 37 | 37 | 0d | 0d |
| 29 | 29-Erect interior wall partitions [4C] | 3,20,26 | 4d | 7ed | 37 | 44 | 44 | 48 | 48 | 48 | 0d | 0d |
| 30 | 30-Cleanup [4L] | 27,28,29 | 2d | 0ed | 48 | 48 | 48 | 50 | 50 | 50 | 0d | 0d |
| 3 | 03-Fabricate interior wall partition [4C] | 2 | 8d | 0ed | 4 | 4 | 29 | 12 | 12 | 37 | 25d | 25d |
| 10 | 10-Place drain pipes [SUB] | 6 | 1d | 0ed | 5 | 5 | 25 | 6 | 6 | 26 | 12d | 20d |
| 5 | 05-Fabricate timber trusses [4C] | 2 | 4d | 10ed | 4 | 14 | 15 | 18 | 18 | 19 | 1d | 1d |
| 4 | 04-Fasten wood strips to purlins [2C] | 2 | 2d | 14ed | 4 | 18 | 20 | 20 | 20 | 22 | 2d | 2d |
| 14 | 14-Backfill, compact & grade slab [2L] | 10,31 | 2d | 0ed | 18 | 18 | 26 | 20 | 20 | 28 | 0d | 8d |
| 16 | 16-Forms, rebar & drains floor slab [4C,2I] | 14 | 1d | 0ed | 20 | 20 | 28 | 21 | 21 | 29 | 0d | 8d |
| 18 | 18-Pour slab [1C,2L] | 13,16 | 1d | 0ed | 21 | 21 | 29 | 22 | 22 | 30 | 0d | 8d |
| 8 | 08-Const. plywood ext. wall panel [4C] | 2 | 12d | 18ed | 4 | 22 | 24 | 34 | 34 | 36 | 0d | 2d |
| 20 | 20-Cure slab | 18 | 6d | 0ed | 22 | 22 | 30 | 28 | 28 | 36 | 6d | 8d |
| 7 | 07-Fabricate exterior doors [2C] | 2 | 7d | 30ed | 4 | 34 | 38 | 41 | 41 | 45 | 2d | 4d |
| 28 | 28-Erect corrugated roofing [2C] | 26 | 2d | 0ed | 37 | 37 | 46 | 39 | 39 | 48 | 9d | 9d |
| 22 | 22-Erect ext. wall panels [4C] | 20,8 | 2d | 7ed | 34 | 41 | 43 | 43 | 43 | 45 | 0d | 2d |
| 24 | 24-Erect doors [2C] | 7,22 | 1d | 0ed | 43 | 43 | 45 | 44 | 44 | 46 | 0d | 2d |
| 25 | 25-Waterproof & insulate joints [2L] | 22 | 1d | 0ed | 43 | 43 | 45 | 44 | 44 | 46 | 0d | 2d |
| 27 | 27-Paint ext. walls [SUB] | 24,25 | 2d | 0ed | 44 | 44 | 46 | 46 | 46 | 48 | 2d | 2d |

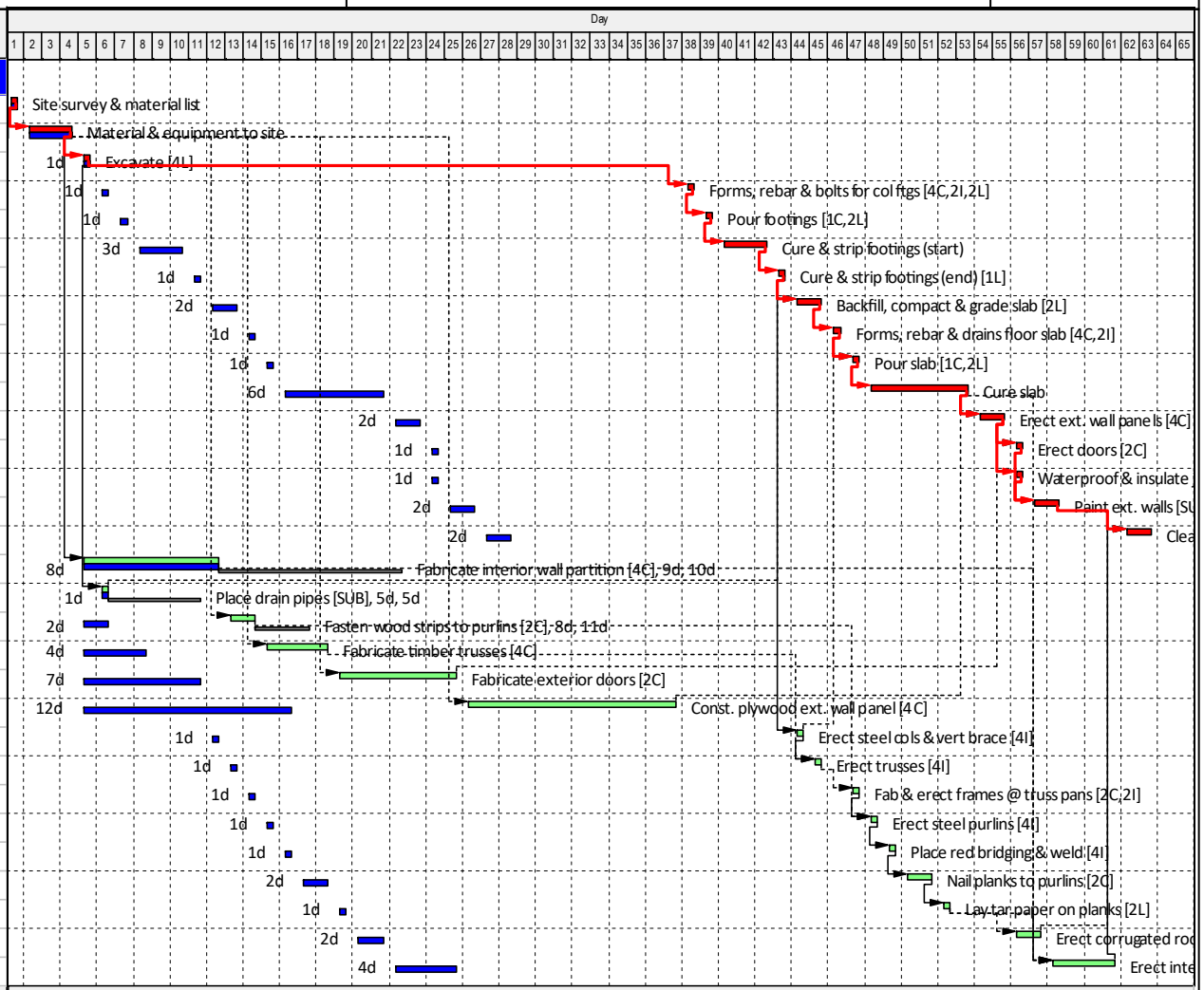



| ID | Resource Name | Work | Details |
|---|---|---|---|
| | Unassigned | 0d | Work |
| 1 | Carpenters | 160d | Work |
| 2 | Ironworkers | 22d | Work |
| 3 | Laborers | 27d | Work |

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.

| Primavera P6 Professional R20.12 | Project: WH-After CO-No Splits-Def Lvl-T=63d | Layout: 2021F-Lab6.5-CO-Default_Leveling | Date: 01-12-21 |
|---|---|---|---|

| ID | Act | Pred | Orig Dur | FF | TF |
|---|---|---|---|---|---|
| **WH-After CO-No Splits-Def Lvl-T=63d** | | | 63d | 0d | 0d |
| 01 | Site survey & material list | | 1d | 0d | 0d |
| 02 | Material & equipment to site | 01 | 3d | 0d | 0d |
| 06 | Excavate [4L] | 02 | 1d | 0d | 0d |
| 09 | Forms, rebar & bolts for col ftgs [4C,2I,2L] | 06 | 1d | 0d | 0d |
| 11 | Pour footings [1C,2L] | 09 | 1d | 0d | 0d |
| 12A | Cure & strip footings (start) | 11 | 3d | 0d | 0d |
| 12B | Cure & strip footings (end) [1L] | 12A | 1d | 0d | 0d |
| 14 | Backfill, compact & grade slab [2L] | 10, 12B | 2d | 0d | 0d |
| 16 | Forms, rebar & drains floor slab [4C,2I] | 14 | 1d | 0d | 0d |
| 18 | Pour slab [1C,2L] | 13, 16 | 1d | 0d | 0d |
| 20 | Cure slab | 18 | 6d | 0d | 0d |
| 22 | Erect ext. wall panels [4C] | 20, 08 | 2d | 0d | 0d |
| 24 | Erect doors [2C] | 07, 22 | 1d | 0d | 0d |
| 25 | Waterproof & insulate joints [2L] | 22 | 1d | 0d | 0d |
| 27 | Paint ext. walls [SUB] | 24, 25 | 2d | 0d | 0d |
| 30 | Cleanup [4L] | 27, 28, 29 | 2d | 0d | 0d |
| 03 | Fabricate interior wall partition [4C] | 02 | 8d | 9d | 10d |
| 10 | Place drain pipes [SUB] | 06 | 1d | 5d | 5d |
| 04 | Fasten wood strips to purlins [2C] | 02 | 2d | 8d | 11d |
| 05 | Fabricate timber trusses [4C] | 02 | 4d | 4d | 7d |
| 07 | Fabricate exterior doors [2C] | 02 | 7d | 12d | 12d |
| 08 | Const. plywood ext. wall panel [4C] | 02 | 12d | 5d | 5d |
| 13 | Erect steel cols & vert brace [4I] | 12B | 1d | 0d | 2d |
| 15 | Erect trusses [4I] | 13, 05 | 1d | 0d | 3d |
| 17 | Fab & erect frames @ truss pans [2C,2I] | 15 | 1d | 0d | 3d |
| 19 | Erect steel purlins [4I] | 04, 17 | 1d | 0d | 3d |
| 21 | Place red bridging & weld [4I] | 19 | 1d | 0d | 3d |
| 23 | Nail planks to purlins [2C] | 21 | 2d | 0d | 3d |
| 26 | Lay tar paper on planks [2L] | 23 | 1d | 0d | 3d |
| 28 | Erect corrugated roofing [2C] | 26 | 2d | 5d | 5d |
| 29 | Erect interior wall partitions [4C] | 03, 20, 26 | 4d | 1d | 1d |




| Activity ID | | Remaining Units | Budgeted Units |
|---|---|---|---|
| **Total** | | 209 | |
| Resource ID Name: C | Carpenters | 160 | |
| Resource ID Name: I | Ironworkers | 22 | |
| Resource ID Name: L | Laborers | 27 | |

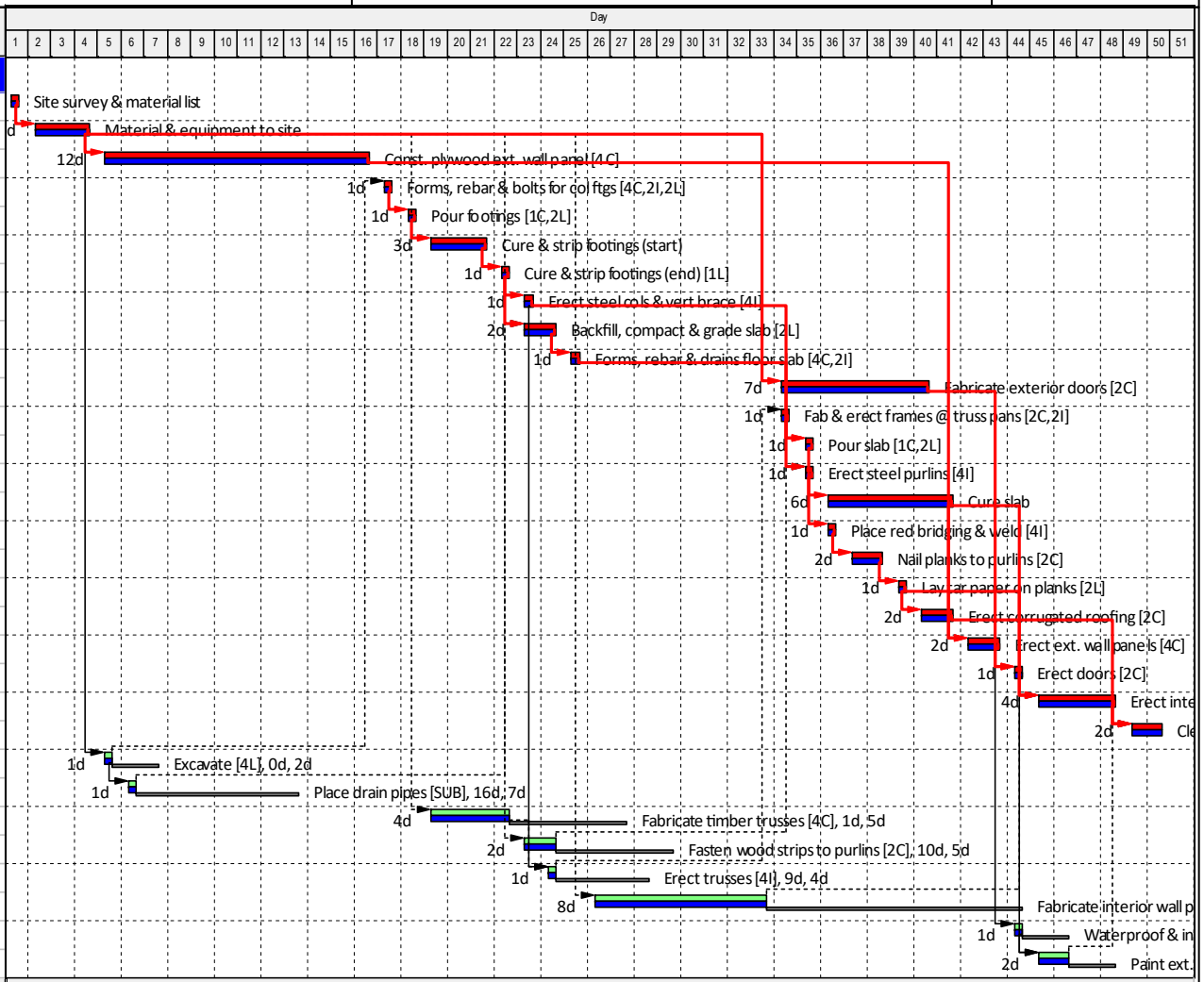
Critical Rem Work
Float Bar
Remaining Work
Early Bar

| Date | Revision | Check... | Approved |
|---|---|---|---|
| 1-12-21 | After Change Order - Default leveling, T=63d | PGI | PGI |
| | (To print all 3 res rows in sprdsht, select them on screen) | | |
| | Sorted by: Critical, Start, Activity ID | | |

Course: CEE538
User: P.G. Ioannou

| Primavera P6 Professional R20.12 | Project: WH-After CO-No Splits-TF Lvl-T=50d | Layout: 2021F-Lab6.6-CO-TF_Leveling | Date: 01-12-21 |
|---|---|---|---|

| ID | Act | Pred | Orig Dur | FF | TF |
|---|---|---|---|---|---|
| **WH-After CO-No Splits-TF Lvl-T=50d** | | | 50d | 0d | 0d |
| 01 | Site survey & material list | | 1d | 0d | -9d |
| 02 | Material & equipment to site | 01 | 3d | 0d | -9d |
| 08 | Const. plywood ext. wall panel [4C] | 02 | 12d | 25d | -9d |
| 09 | Forms, rebar & bolts for col ftgs [4C,2I,2L] | 06 | 1d | 0d | -9d |
| 11 | Pour footings [1C,2L] | 09 | 1d | 0d | -9d |
| 12A | Cure & strip footings (start) | 11 | 3d | 0d | -9d |
| 12B | Cure & strip footings (end) [1L] | 12A | 1d | 0d | -9d |
| 13 | Erect steel cols & vert brace [4I] | 12B | 1d | 0d | -1d |
| 14 | Backfill, compact & grade slab [2L] | 10, 12B | 2d | 0d | -9d |
| 16 | Forms, rebar & drains floor slab [4C,2I] | 14 | 1d | 9d | -9d |
| 07 | Fabricate exterior doors [2C] | 02 | 7d | 3d | -17d |
| 17 | Fab & erect frames @ truss pans [2C,2I] | 15 | 1d | 0d | -5d |
| 18 | Pour slab [1C,2L] | 13, 16 | 1d | 0d | -12d |
| 19 | Erect steel purlins [4I] | 04, 17 | 1d | 0d | -5d |
| 20 | Cure slab | 18 | 6d | 0d | -12d |
| 21 | Place red bridging & weld [4I] | 19 | 1d | 0d | -5d |
| 23 | Nail planks to purlins [2C] | 21 | 2d | 0d | -5d |
| 26 | Lay tar paper on planks [2L] | 23 | 1d | 0d | -5d |
| 28 | Erect corrugated roofing [2C] | 26 | 2d | 7d | -5d |
| 22 | Erect ext. wall panels [4C] | 20, 08 | 2d | 0d | -12d |
| 24 | Erect doors [2C] | 07, 22 | 1d | 0d | -8d |
| 29 | Erect interior wall partitions [4C] | 03, 20, 26 | 4d | 0d | 0d |
| 30 | Cleanup [4L] | 27, 28, 29 | 2d | 0d | 0d |
| 06 | Excavate [4L] | 02 | 1d | 0d | 2d |
| 10 | Place drain pipes [SUB] | 06 | 1d | 16d | 7d |
| 05 | Fabricate timber trusses [4C] | 02 | 4d | 1d | 5d |
| 04 | Fasten wood strips to purlins [2C] | 02 | 2d | 10d | 5d |
| 15 | Erect trusses [4I] | 13, 05 | 1d | 9d | 4d |
| 03 | Fabricate interior wall partition [4C] | 02 | 8d | 11d | 11d |
| 25 | Waterproof & insulate joints [2L] | 22 | 1d | 0d | 2d |
| 27 | Paint ext. walls [SUB] | 24, 25 | 2d | 2d | 2d |




| Activity ID | Remaining Units | Budgeted Units |
|---|---|---|
| **Total** | 209 | |
| Resource ID Name: C Carpenters | 160 | |
| Resource ID Name: I Ironworkers | 22 | |
| Resource ID Name: L Laborers | 27 | |

Critical Rem Work
Float Bar
Remaining Work
Early Bar

| Date | Revision | Check... | Approved |
|---|---|---|---|
| 1-12-21 | After Change Order - Repeated TF leveling, T=50d | PGI | PGI |
| | (To print all 3 res rows in sprdsht, select them on screen) | | |
| | Sorted by: Critical, Start, Activity ID | | |

Course: CEE538
User: P.G. Ioannou

**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 (3d) | 12A (3d) | 0 | C | - | - | - | C |
| 31 (1d) | 12B (1d) | 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) |
| **12** (4d) | = | **12** (3d) + **31** (1d) | **12A** (3d) + **12B** (1d) |

This enables MS Project and P6 (neither of which can split activities automatically when leveling resources) to "split" into two activities each of the three activities 5, 8, and 12, as described by Fondahl (1991).

**Provide short answers to the following (easy) questions:**

Use the MS Project Resource Usage report to verify that the Warehouse Project (after the Change Order) has a total amount of 160 mandays of work for the carpenters (more than double the 78 mandays before the Change Order). Consider also the following:

- Activity "*Site survey & material list*" (1d) and its successor activity "*Material & equipment to site*" (3d), must precede all other activities in the network and that both activities do not require any carpenters.
- There is only one finish activity, "*Cleanup*" (2d), which is a successor to all other activities, and it does not require any carpenters, either.

Based on these observations alone,

1. What is the minimum possible duration for the Warehouse Project (even when each of the rest of the activities could be split as many times as might be needed) given that there are only 4 carpenters available?
2. How should these simple observations be presented by the contractor to explain to the project owner the impact of the Change Order on the project schedule and the increase of the project duration from 28d to 50d? Explain.
3. The following table shows the duration of the project (after the change order) produced by MS Project (with default and with priority leveling), P6 (with default and with TF leveling), Fondahl's manual leveling, and P3. What do you conclude?

| MS Project Default | MS Project Priority(A03)=600 | P6 Pro Default | P6 Pro TF Leveling | Fondahl (Manual) | P3 Leveling |
|---|---|---|---|---|---|
| 54d | 50d | 63d | 50d | 50d | 52d |

4. Compare the two solutions produced by MS Project. Compare the two solutions produced by P6 Pro. What are some practical conclusions for users of these programs?

**Use the following quotes from Fondahl's article to answer the questions below:**

"The changes made [by the Change Order] were all within the activity's […] free float periods. [Yet] Because resource restrictions governed, the project was actually extended in duration by almost 80%. In such a situation, it is quite likely that neither contractor nor owner, in the absence of a resource-leveled schedule, would fully appreciate just why the project was gradually turning into a disaster.
This brings up another related problem. *Few of even those who claim to be "CPM experts" fully appreciate the fact that in a resource-restrained schedule the concept of float breaks down and quite often the concept of a critical path breaks down.*"

5. What does Fondahl mean by: "*in a resource-restrained schedule the concept of float breaks down*"?
6. What does Fondahl mean by: "*in a resource-restrained schedule… the concept of a critical path breaks down*"?

"Since almost all construction projects are resource-restrained, at least to some extent, this becomes a source of major problems. The classic legal question in recent years, as well as the subject of numerous professional papers, is, "*Who owns float time*?" It is difficult to claim ownership of something that might not exist or that hasn't been quantified properly."

7. What does Fondahl mean by: "*It is difficult to claim ownership of something that might not exist or that hasn't been quantified properly.*"?

These are fundamental matters that after 30 years still don't seem to be understood.
More importantly, the results shown in these simple problems indicate that the conventional concepts of "*float time"* break down in a resource-constrained project. "*Float times"* may be much less than those computed, or may not exist at all, and *project duration may not be determined by the conventionally calculated critical path*. Again, since almost any construction project either must be resource-leveled to achieve a feasible solution or should be resource-leveled to achieve an economic solution, we have a problem that is almost always present but seems to be universally ignored. Some, and often many, of the conventional CPM data are not valid. The originally calculated network data, including float data, are useful as a basis for establishing and applying priority rules in heuristic leveling procedures. *However, once leveling has been performed, float times may have little meaning.*

8. What does Fondahl mean by: "*The originally calculated network data, including float data, are useful as a basis for establishing and applying priority rules in heuristic leveling procedures. However, once leveling has been performed, float times may have little meaning.*"?

**Provide short answers to the following questions related to Fondahl's Article**

9. Consider observations (5), (7), and (8). What do you conclude about floats in resource-restrained construction schedules?
10. Given your answer above, what is the best way to define "*Critical Activities*"? (See Fondahl's article for the answer.)
11. Given observation (6), under what (simplifying) conditions does a schedule *really* have a "*Critical Path*", and what then is the appropriate (complete) definition of a "*Critical Path*" (= longest path)?
12. Is there a critical path in your MS Project and P6 schedules after the resources are leveled? Explain your answer.

**Lab 6-Part 2 Assignment Deliverables**

**1. Lab 6 Part 2 Report** (one PDF file submitted on Canvas)

Start with a discussion that describes the project and the change order. Describe the five scheduling reports by MS Project and P6 and explain how they were produced and why. Use the following scheduling reports to provide answers to all the numbered questions above.

MS Project: Three "Gantt Chart and Resource Usage" combination reports (like the ones for Part 1) for the 28-day, 54-day, and 50-day schedules (no network report is needed).

P6 Pro: Two "Gantt Chart and Resource Spreadsheet" combination reports (like the ones for Part 1) one for the 63-day schedule and one for the 50-day schedule (i.e., one report for leveling using the default settings and one report for leveling using TF as the leveling criteria).

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

As usual.