Case Twenty-Five

Fox Hill Development

Fox Hill Development (FHD) has been in the business of constructing single-family residential homes for a number of years. FHD selectively acquires large parcels of property in different geographic areas and then oversees the construction of all homes in the resulting development after the parcel is approved for subdivision by local government authorities. Since the start of the business, FHD has built more than 2,000 homes. FHD employs their own specialized teams of workers to do work in the 12 specialty fields that are required for constructing houses. FHD finds that it is beneficial to have these specialty teams as their own employees, rather than being reliant on independent subcontractors. This is particularly important when there is a critical need to get one of these activities completed on a priority basis.

The 12 specialty areas are:

- Excavation (Exc): This includes all necessary excavation for the basement and digging all trenches for the placement of water and sewer lines.
- Concrete (Con): This activity includes the preliminary laying of drainpipe below the basement floor, and the pouring of all concrete for the basement floor, driveway, and basement walls.
- Sewer and Water (S&W): This includes running both the sewer and water lines from the road to the main hookups in the basement.
- Structure (Str): This includes installation of the living space floor over the basement; putting up studs for all walls, roof and ceilings; putting on a rough exterior siding; placing a rough waterproof covering over the rough outside siding and roof; installing insulation; and the insertion of all exterior windows and doors.
- Electric (Ele): This includes running the main electric power line to the house, installing the main circuit box, and running all electrical wires for the fixtures.
- Rough Plumbing (RPl): This includes the installation of all copper pipes and plastic tubing inside the walls of the structure for all sewer and water fixtures.
- Walls and Cabinets (W&C): This includes the application of all drywall and the placement of kitchen cabinets.
- Finish Plumbing (FPl): This includes the placement of all plumbing fixtures and the installation of a hot-water heating system that is the primary heat source for the house.

- Roofing and Siding (R&S): This includes the installation of the roofing material, rain gutters and exterior siding over part of the house.
- Inside Finish (IF): This includes all finish plastering, painting, carpet installation, trim work, and other activities to complete the inside of the house.
- Brick Work (BW): This includes the application of bricks to parts of the exterior of the house and some decorative stonework around the house.
- Outside Finish (OF): This includes the final leveling of the yard area, the spreading of an adequate layer of topsoil, placement of sod for the lawn, and other landscaping work.

There are a number of precedence restrictions on the order in which some of these activities can be completed. Neither Concrete nor Sewer and Water can start until excavation is complete. Structure can only start after Concrete is done. Sewer and Water must be completed before Rough Plumbing can begin. Structure must be completed before any of Roofing and Siding, Electric, and Rough Plumbing can begin. Rough Plumbing and Electric must both be completed before Walls and Cabinets can be started. Roofing and Siding must be done before Brick Work, and Brick Work must be done before Outside Finish can begin. Walls and Cabinets must be done before Finish Plumbing, and both Finish Plumbing and Roofing and Siding must be done before Inside Finish can start.

The homes built by FHD do have some limited variation in their design, but the amount of work required from any given specialty group is effectively the same for each house that FHD builds. There has been variation in the completion times for activities of the specialty teams for different houses. The overriding factor for activity completion time has been the amount of time that FHD has allowed the specialty teams to complete the specific activities in each particular case. Specialty teams report in at the completion of work on each house, and they are assigned to work at another site. At that time they are told how many workdays they have available to get the activity completed. By resorting to the use of overtime, second-shift work, rental of extra equipment, and other methods, each of the specialty team supervisors has generally been able to meet the activity time limitations that have been imposed on them by FHD for each specific house. Exhibit 25.1 shows the activity times that were assigned to each of the specialty teams over the last 20 homes built by FHD. The differences in the activity times for different houses are not due to conditions such as weather, but simply reflect the amount of time that specialty teams were assigned for completion of their respective activities in each specific house. Nothing unusual happened during these observations, and the assigned activity times represent the range of what could normally be expected. Times are expressed in units of workdays.

Exhibit 25.2 shows the associated specialty team costs to FHD to have the activities completed within the times that were specified by FHD for each of the last 20 houses. The costs in Exhibit 25.2 include fixed costs for materials that are used in the associated activities. For example, the costs associated with structural work include all cost for lumber, trusses, and other structural material. As might be expected, the cost to have an activity completed in a shorter amount of time is generally greater than what would be expected if more time were to be allowed for completion. Obviously, there is an upper limit on how much can be saved by allowing more time to do an activity, and

EXHIBIT 25.1 Number of Working Days Allocated for Specialty Group Activities

Home	Exc.	Con.	S&W	Str.	Ele.	W&C	RPl	FPl	R&S	IF	BW	OF
1	5.0	11.0	4.0	58.0	4.5	9.0	5.0	5.0	15.5	5.0	7.5	7.0
2	6.0	7.0	6.5	67.0	4.0	11.0	3.0	6.0	15.5	7.5	8.0	6.5
3	4.0	11.5	5.0	60.0	4.0	9.5	5.0	5.5	14.0	8.0	7.0	7.5
4	4.5	12.0	4.5	53.0	7.0	7.5	8.5	4.5	16.0	6.5	5.5	9.0
5	5.0	10.5	5.0	46.0	4.0	9.0	2.5	5.5	15.0	13.0	6.0	5.5
6	4.5	11.5	5.5	57.0	5.0	8.5	4.5	3.5	17.5	7.5	9.0	6.5
7	5.0	13.0	6.5	68.0	5.5	10.0	6.0	5.0	20.0	9.5	10.0	8.0
8	5.5	11.0	3.5	65.0	4.5	11.5	3.5	4.5	15.5	5.5	6.5	7.0
9	4.5	11.5	6.0	55.0	9.5	10.5	7.0	5.0	14.0	8.5	8.0	6.0
10	4.5	10.0	4.5	60.0	5.0	9.5	7.5	6.0	18.5	8.0	7.0	9.5
11	6.0	12.5	5.0	58.0	4.5	9.0	9.0	5.5	15.0	7.0	5.0	11.0
12	5.0	10.0	4.0	57.0	5.5	8.5	6.0	4.5	16.5	6.0	9.5	6.5
13	5.5	11.5	4.5	64.0	3.5	9.5	13.5	6.5	15.0	7.5	4.5	6.5
14	5.0	11.0	5.0	54.0	5.0	10.0	6.0	5.0	14.5	10.5	6.0	8.0
15	4.5	12.5	6.0	60.0	6.5	11.0	5.0	4.5	16.5	8.0	7.0	6.5
16	5.0	12.0	5.5	66.0	5.0	10.5	4.5	4.0	14.5	12.0	4.0	5.0
17	5.0	11.5	4.0	63.0	7.5	9.5	3.5	5.0	17.0	7.5	8.5	5.5
18	6.0	10.5	4.5	51.0	8.0	9.5	4.5	5.0	15.5	9.0	6.5	7.5
19	5.5	11.0	5.0	56.0	6.5	8.0	10.5	4.5	18.0	7.0	7.5	6.0
20	4.0	8.5	5.5	62.0	5.0	8.5	5.0	5.0	16.0	6.5	7.0	5.0

EXHIBIT 25.2 Costs for Associated Specialty Group Activities (in Dollars)

Home	Exc.	Con.	S&W	Str.	Ele.	W&C	RPl	FPl	R&S	IF	BW	OF
1	5,438	4,531	5,210	19,213	5,757	8,317	7,740	5,989	6,988	5,859	5,507	6,408
2	4,822	6,451	3,708	18,013	5,679	7,297	7,987	5,804	6,839	5,401	5,786	6,499
3	6,105	4,434	4,693	18,775	5,611	8,002	7,476	6,187	7,049	5,188	5,975	6,317
4	5,635	4,170	4,887	20,503	4,439	8,478	6,548	6,637	6,745	5,821	6,689	6,180
5	5,520	4,756	5,017	20,716	5,541	7,018	8,346	5,724	7,302	4,177	6,289	6,511
6	5,670	4,233	4,287	21,254	5,210	7,982	7,879	7,306	6,690	5,070	4,889	6,410
7	5,168	3,857	3,856	18,432	5,368	7,571	7,201	5,956	6,088	4,751	4,836	6,375
8	5,079	4,955	5,683	18,789	5,766	7,088	7,752	6,461	6,917	5,488	5,904	6,436
9	5,988	4,386	4,154	19,612	3,931	7,634	6,888	5,939	7,126	4,855	5,751	6,400
10	5,838	5,235	5,406	19,684	5,377	7,988	6,648	5,868	6,279	5,175	5,847	6,330
11	4,520	4,243	4,502	19,666	5,466	7,912	6,231	5,941	6,849	5,465	6,609	6,077
12	5,283	5,488	4,867	21,255	5,299	8,514	7,148	6,324	6,587	5,399	5,148	6,366
13	5,024	4,741	4,667	18,545	5,766	7,878	4,886	5,258	6,909	5,385	7,221	6,597
14	5,545	4,138	4,945	19,678	5,367	7,977	7,090	5,999	7,228	4,651	6,212	6,568
15	5,609	3,703	4,294	19,676	5,179	7,665	7,731	6,759	6,988	5,188	5,685	6,488
16	5,491	4,432	4,387	17,688	5,553	7,599	7,879	6,679	7,075	4,465	7,435	6,557
17	5,340	4,498	5,457	18,256	4,419	7,980	7,945	6,192	6,544	5,288	5,545	6,533
18	4,391	4,611	4,657	21,135	4,549	8,031	7,588	6,458	6,819	4,998	6,098	6,302
19	5,173	5,587	4,738	19,812	4,941	8,611	5,950	6,438	6,335	5,233	5,065	6,589
20	6,069	5,890	4,675	19,145	5,272	8,354	7,458	6,356	6,988	5,222	5,830	6,554

no additional savings can be expected if more time is allowed than the maximum activity times that have been observed.

It can be seen that different activity costs can be incurred for different situations with the same activity completion time. These variations result from conditions, such as weather, that existed at the time the respective activities were completed. The specialty teams completed their activities in the assigned times in each case, and conditions such as weather required different measures, and associated costs, in order to meet the assigned completion time for the activity. No extreme measures were taken to meet the assigned times during these observations, and FHD does not wish to consider doing so at any time in the future.

PROJECT MANAGEMENT PROBLEMS

FHD management is considering the option of making some changes in its operating procedures. Currently, specialty crews are scheduled for work at different sites when they check into the main office after completing work at their previous assigned site. The project management procedure function is not well organized, and the general manager is considering the possibility of improving the procedure of scheduling work crews in order to gain control of the process and to help reduce costs. The problem is complicated by the fact that there is a fixed cost of $450 per day, for each workday of construction on each house, until the house is completed. This cost results from insurance premiums against damage to the house while under construction, from equipment leasing costs for equipment that must remain at the building site during construction, and other related costs. This fixed cost is not included in the activity costs that are given in Exhibit 25.2.

The general manager would like to know the total number of days, and the associated activity time to be scheduled to each of the specialty work crews, that should be allocated to building each house to minimize total cost. This total cost should include the sum of costs for all of the specialty work groups and the $450 per day cost for each day of the duration of the project.

If demand becomes particularly high during some period, the specialty work crews could work on a crash time basis to get the houses done as quickly as possible. Obviously, there are limits on how fast each crew can complete their respective activities. The minimum observed completion time for each activity in Exhibit 25.1 can be assumed to represent the crash time for the associated activity. The manager wants to know the crash completion time for a house, that is, the minimum time it would take to complete a house, which does not necessarily require every activity to be completed in its shortest possible time. In addition, the manager would like to know the minimum additional cost that would be incurred by reducing the number of days allowed for completion of a house, in five-workday increments, from the least-total-cost-construction time down to the crash time to build a house. It is of interest to know the number of workdays that will be assigned for each specialty work crew for each target total completion time as the number of workdays is reduced by five-workday increments.