Appendix

Table A1. The case project information

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| ID | Name | Successors | Expected duration | Resource availability /need |
| **0** | **Dummy work package** | **1,2** | **0** | **0** |
| **1** | **Construction plan** | **3** | **Depend on schedule** | **20** |
| 1.1 | Determine the project scope | 1.3,1.4,1.5 | 1 | 2 |
| 1.2 | Identity construction resource | 1.3,1.4,1.5 | 1 | 10 |
| 1.3 | Create a schedule | 1.6,1.7 | 4 | 8 |
| 1.4 | Develop the budget | 1.6,1.7 | 2 | 18 |
| 1.5 | Assign roles and responsibilities | 1.6,1.7 | 5 | 10 |
| 1.6 | Plan discussion | 1.8 | 2 | 16 |
| 1.7 | Plan update | 1.8 | 3 | 6 |
| 1.8 | Plan review | N/A | 2 | 10 |
| **2** | **Production plan** | **4,5** | **Depend on schedule** | **20** |
| 2.1 | Determine the requirement | 2.3,2.4 | 1 | 12 |
| 2.2 | Site analysis | 2.3,2.4 | 4 | 2 |
| 2.3 | Schematic design | 2.5,2.6 | 4 | 8 |
| 2.4 | Conceptual design | 2.5,2.6 | 2 | 18 |
| 2.5 | Structure plan | 2.7 | 3 | 10 |
| 2.6 | Design development | 2.7 | 1 | 12 |
| 2.7 | Mechanical, electrical, and plumbing plan | 2.8 | 4 | 8 |
| 2.8 | Documentation | N/A | 2 | 10 |
| **3** | **Pile foundation construction** | **8** | **Depend on schedule** | **40** |
| 3.1 | Site preparation | 3.2 | 3 | 12 |
| 3.2 | Soil testing | 3.3 | 1 | 8 |
| 3.3 | Pile layout | 3.4 | 2 | 32 |
| 3.4 | Pile reinforcement | 3.7,3.12 | 2 | 32 |
| 3.5 | Pile drilling | 3.8,3.10,3.12 | 2 | 12 |
| 3.6 | Pile inspection | 3.7 | 5 | 16 |
| 3.7 | Capping beaming reinforcement | 3.8,3.10 | 3 | 24 |
| 3.8 | Excavation | 3.9 | 4 | 28 |
| 3.9 | Gravel bed preparation | 3.11 | 4 | 28 |
| 3.10 | Capping beaming inspection | 3.11 | 1 | 28 |
| 3.11 | Frame work | 3.13 | 8 | 16 |
| 3.12 | Pile capping beam | 3.13 | 3 | 28 |
| 3.13 | Concrete pour | 3.14,3.15 | 7 | 40 |
| 3.14 | Concrete finishing | 3.16,3.18 | 6 | 24 |
| 3.15 | Foundation inspection | 3.16,3.18 | 2 | 20 |
| 3.16 | HVAC rough-in | 3.17 | 1 | 36 |
| 3.17 | Insulation | 3.19 | 8 | 24 |
| 3.18 | Electrical and plumbing rough-in | 3.18 | 10 | 16 |
| 3.19 | Final inspection | 3.20 | 1 | 19 |
| 3.20 | Handover | N/A | 2 | 28 |
| **4** | **Modular materials procurement** | **6** | **Depend on schedule** | **13** |
| 4.1 | Create the detailed list | 4.2,4.3 | 2 | 2 |
| 4.2 | Obtain quotes from suppliers | 4.4 | 1 | 8 |
| 4.3 | Research and identify potential suppliers | 4.4 | 3 | 6 |
| 4.4 | Evaluate the quotes | 4.5,4.6,4.9 | 4 | 5 |
| 4.5 | Receive and inspect the materials | 4.7 | 3 | 7 |
| 4.6 | Place the orders | 4.7 | 4 | 6 |
| 4.7 | Store the materials | 4.8 | 5 | 7 |
| 4.8 | Keep accurate records | 4.10 | 3 | 4 |
| 4.9 | Monitor the progress of the orders | 4.10 | 3 | 8 |
| 4.10 | Deliver materials to production | N/A | 1 | 7 |
| **5** | **Modulars design** | **6** | **Depend on schedule** | **20** |
| 5.1 | Determine the modular type | 5.3,5.4 | 1 | 2 |
| 5.2 | Determine the modular size | 5.3,5.4 | 3 | 4 |
| 5.3 | Allocate the modulars | 5.5,5.6 | 2 | 12 |
| 5.4 | Plan the layout | 5.5,5.6 | 3 | 10 |
| 5.5 | Design the group modulars | 5.7 | 2 | 10 |
| 5.6 | Consider functional requirements | 5.7 | 1 | 12 |
| 5.7 | Create flexibility | 5.8 | 2 | 16 |
| 5.8 | Maintain visual coherence | N/A | 2 | 14 |
| **6** | **Modules production and storage** | **7** | **Depend on schedule** | **25** |
| 6.1 | Materials inspection | 6.2 | 2 | 3 |
| 6.2 | Clear the production specifications | 6.4,6.5 | 5 | 10 |
| 6.3 | Determine the requirements | 6.4,6.5 | 3 | 16 |
| 6.4 | Assemble the frames | 6.6 | 2 | 10 |
| 6.5 | Construct wall panels | 6.6 | 2 | 16 |
| 6.6 | Install electrical and plumbing | 6.7 | 4 | 16 |
| 6.7 | Install windows and exterior doors | 6.8,6.9 | 3 | 17 |
| 6.8 | Install interior and exterior partition | 6.10,6.11 | 3 | 21 |
| 6.9 | Install flooring and ceiling finish | 6.10,6.11 | 4 | 12 |
| 6.10 | Install roofing and siding | 6.12,6.14 | 4 | 12 |
| 6.11 | Connect the wall panels | 6.12 | 4 | 17 |
| 6.12 | Install interior fixtures and appliances | 6.13 | 2 | 10 |
| 6.13 | Conduct quality control | 6.15 | 4 | 17 |
| 6.14 | Production documents | 6.15 | 4 | 16 |
| 6.15 | Modulars store | N/A | 1 | 7 |
| **7** | **Modules transportation** | **9** | **Depend on schedule** | **30** |
| 7.1 | Plan the transportation route | 7.2,7.3 | 4 | 3 |
| 7.2 | Load the modulars on the vehicle | 7.4,7.9 | 1 | 15 |
| 7.3 | Prepare the modulars | 7.4,7.9 | 3 | 21 |
| 7.4 | Secure the modulars | 7.5,7.6 | 2 | 18 |
| 7.5 | Drive the transport vehicle to the site | 7.7 | 2 | 24 |
| 7.6 | Obtain the necessary permit | 7.7 | 1 | 18 |
| 7.7 | Unload the modulars | 7.8 | 2 | 15 |
| 7.8 | Position the modulars | 7.10 | 2 | 15 |
| 7.9 | Inspect the modulars and restrains | 7.10 | 3 | 6 |
| 7.10 | Modulars inspection | N/A | 2 | 15 |
| **8** | **Underground structure construction** | **9,11** | **Depend on schedule** | **40** |
| 8.1 | Excavation | 8.2 | 2 | 4 |
| 8.2 | Soil preparation | 8.3 | 2 | 16 |
| 8.3 | Footing construction | 8.4,8.5,8.6 | 5 | 20 |
| 8.4 | Drainage system | 8.7,8.12 | 5 | 24 |
| 8.5 | Foundation walls | 8.8,8.10,8.12 | 2 | 24 |
| 8.6 | Water proofing | 8.7 | 4 | 26 |
| 8.7 | Electrical and plumbing rough-in | 8.8,8.10 | 2 | 20 |
| 8.8 | Insulation | 8.9 | 2 | 28 |
| 8.9 | Framing | 8.11 | 3 | 32 |
| 8.10 | HVAC rough-in | 8.11 | 2 | 20 |
| 8.11 | Electrical and plumbing rough-in inspection | 8.13 | 3 | 32 |
| 8.12 | Floor slab | 8.13 | 4 | 36 |
| 8.13 | Electrical and plumbing final inspection | 8.14,8.15 | 3 | 24 |
| 8.14 | HVAC rough-in inspection | 8.16,8.17 | 2 | 36 |
| 8.15 | HVAC final inspection | 8.16,8.17 | 4 | 28 |
| 8.16 | Drywall installation | 8.18 | 4 | 12 |
| 8.17 | Floor installation | 8.18 | 3 | 32 |
| 8.18 | Painting | 8.19 | 2 | 24 |
| 8.19 | Final inspection | 8.20 | 2 | 24 |
| 8.20 | Handover | N/A | 2 | 24 |
| **9** | **Modulars enter the field** | **10** | **Depend on schedule** | **18** |
| 9.1 | Assess the site | 9.3,9.4 | 2 | 2 |
| 9.2 | Plan the layout | 9.4,9.6 | 5 | 8 |
| 9.3 | Transport the modular | 9.5,9.6 | 2 | 7 |
| 9.4 | Prepare the foundation | 9.5 | 4 | 8 |
| 9.5 | Position the modular | 9.7 | 4 | 7 |
| 9.6 | Interior inspection | 9.7 | 2 | 8 |
| 9.7 | Exterior cover | 9.8 | 2 | 8 |
| 9.8 | General inspection | N/A | 1 | 6 |
| **10** | **Modulars connection** | **11** | **Depend on schedule** | **30** |
| 10.1 | Modulars inspection | 10.2 | 2 | 3 |
| 10.2 | Cleaning and leveling the surface | 10.4,10.5 | 2 | 12 |
| 10.3 | Plan the connection | 10.4,10.5 | 4 | 18 |
| 10.4 | Determine the connection point | 10.6 | 3 | 18 |
| 10.5 | Install the connect plates | 10.6 | 1 | 6 |
| 10.6 | Install the connection foundation | 10.7,10.9 | 1 | 6 |
| 10.7 | Move the modulars | 10.8 | 2 | 18 |
| 10.8 | Position the modulars | 10.10,10.11 | 3 | 9 |
| 10.9 | Install the temporary braces | 10.10,10.11 | 4 | 18 |
| 10.10 | Attach the connector plates | 10.12,10.14 | 3 | 21 |
| 10.11 | Align the connector plates | 10.12 | 5 | 24 |
| 10.12 | Remove the temporary braces | 10.13 | 3 | 12 |
| 10.13 | Seal the gaps between modulars | 10.15 | 4 | 21 |
| 10.14 | Countercheck the connectors | 10.15 | 1 | 18 |
| 10.15 | Quality check | N/A | 2 | 12 |
| **11** | **Above ground structure construction** | **12** | **Depend on schedule** | **40** |
| 11.1 | Site preparation | 11.2 | 2 | 8 |
| 11.2 | Foundation installation | 11.3 | 4 | 4 |
| 11.3 | Framing plan | 11.4,11.5,11.6 | 2 | 20 |
| 11.4 | Determine the size | 11.8,11.12 | 3 | 32 |
| 11.5 | Cut the steel columns and beams | 11.7,11.12 | 5 | 36 |
| 11.6 | Install anchor bolts | 11.7 | 2 | 28 |
| 11.7 | Install diagonal bracing | 11.8 | 2 | 16 |
| 11.8 | Secure the diagonal bracing | 11.9,11.10 | 2 | 28 |
| 11.9 | Secure the horizontal bracing | 11.11 | 3 | 20 |
| 11.10 | Install horizontal bracing | 11.11 | 2 | 32 |
| 11.11 | Install roof trusses | 11.13 | 3 | 40 |
| 11.12 | Position the steel columns | 11.13 | 4 | 20 |
| 11.13 | Attach the steel | 11.14,11.15 | 4 | 40 |
| 11.14 | Lifting the roof trusses | 11.16,11.17 | 3 | 20 |
| 11.15 | Install steel beams | 11.16,11.17 | 1 | 40 |
| 11.16 | Attach steel purlins | 11.18 | 2 | 16 |
| 11.17 | Install steel purlins | 11.18 | 2 | 24 |
| 11.18 | Install steel ridge beams | 11.19 | 2 | 20 |
| 11.19 | Attach the steel ridge | 11.20 | 4 | 12 |
| 11.20 | Handover | N/A | 1 | 24 |
| 12 | **Lifting and installation works** | **13** | **Depend on schedule** | **40** |
| 12.1 | Plan the lift | 12.2 | 1 | 4 |
| 12.2 | Determine the crane capacity | 12.3 | 1 | 24 |
| 12.3 | Site preparation | 12.4,12.5,12.6 | 1 | 24 |
| 12.4 | Attach slings | 12.7,12.11 | 2 | 32 |
| 12.5 | Position the crane | 12.8,12.11 | 1 | 16 |
| 12.6 | Install brackets | 12.7 | 2 | 36 |
| 12.7 | Monitor the position | 12.7 | 2 | 20 |
| 12.8 | Correct the position | 12.8 | 3 | 20 |
| 12.9 | Position inspection | 12.12 | 3 | 16 |
| 12.10 | Shims to adjust | 12.12 | 2 | 28 |
| 12.11 | Lift the modular | 12.12 | 3 | 24 |
| 12.12 | Secure the modular to the foundation | 12.13 | 2 | 28 |
| 12.13 | Interior inspection | 12.14,12.15 | 2 | 16 |
| 12.14 | Modular quality check | 12.16,12.17 | 3 | 24 |
| 12.15 | Electrical, plumbing and HVAC inspection | 12.16,12.17 | 1 | 20 |
| 12.16 | Roof inspection | 12.18 | 2 | 36 |
| 12.17 | Install extra required stairs | 12.18 | 3 | 32 |
| 12.18 | Connect the utilities | 12.19 | 2 | 36 |
| 12.19 | Final inspection | 12.20 | 2 | 24 |
| 12.20 | Handover | N/A | 1 | 20 |
| **13** | **Project acceptance** | **14** | **Depend on schedule** | **12** |
| 13.1 | Confirm completion of all tasks | 13.3,13.4 | 2 | 1 |
| 13.2 | Review project deliverables | 13.3,13.4 | 5 | 5 |
| 13.3 | Obtain sign-off from stakeholders | 13.5,13.6 | 4 | 5 |
| 13.4 | Testing and evaluation | 13.5 | 3 | 5 |
| 13.5 | Obtain the final payment | 13.7 | 3 | 5 |
| 13.6 | Document and acceptance | 13.7 | 3 | 8 |
| 13.7 | Close out the project | 13.8 | 2 | 10 |
| 13.8 | Conduct a post-project review | N/A | 1 | 7 |
| **14** | **Dummy work package** | **N/A** | **0** | **0** |