CONSTRUCTION SITE LAYOUT PLANNING

1. Introduction

Most construction sites that run into trouble do so for reasons related to managerial factors rather than because of technical problems. The site-based management can make significant improvements in the cost and time savings during the construction process without involving a mass of additional work. The role of site managers is to control and maintain work performance and then taking actions to rectify situations where performance is unsatisfactory.

Site management, in general, involves many tasks, such as site investigation before construction process starts, material delivery and procurement management, keeping better site records, keeping good site communication and high level of information flow, monitoring performance regularly, establishing a well co-ordination system among different parts, and performing a good site layout planning.

Among the important tasks of site management is the ***site layout planning***. Extensive time loss and cost overruns could result in large projects, where the number of manpower, subcontractors, and equipment involved are high, if there is no effective and systematic approach to site planning. A detailed planning of the site layout and location of temporary facilities can enable the management to make considerable improvement by minimizing travel time, waiting time, and increasing worker morale by showing better and safer work environment. Due to its importance, this research focuses on the site layout planning problem.

Construction site layout involves identifying, sizing, and placing temporary facilities (TFs) within the boundaries of construction site. These temporary facilities range from simple lay-down areas to warehouses, fabrication shops, maintenance shops, batch plant, and residence facilities. Required temporary facilities and their areas are depending in many factors including project type, scale, design, location, and organization of construction work.

Site planning in particular, has been the most neglected aspect in the construction industry and the attitude of the engineers has been that it will be done as the project progress. It is important to realize that the site planning will be the conditions that site personnel will live with for the total duration of the construction period. Thus the careful pre-planning is imperative. Also, since the labor cost on a large project constitute approximately 50 to 60 percent of the total project cost, significant saving can be occurred if the labor force moved freely and quickly within the site. In 1987, the Construction Industry Institute reported in its “Constructability Concepts File” that temporary facilities are important elements that can either enhance or adversely affect construction productivity.

Layout planning, in general, can be viewed as a complex optimization problem that has many engineering applications ranging from the layout of manufacturing plants to the layout of computer chips on a board. Since the early 1960's, the problem has been extensively analyzed in the Industrial Engineering and Operational Research communities. However, it has not been satisfactory analyzed in the construction domain.

There are two general objectives which planners should seek to meet through careful organization of the site for construction. First, the site must be designed to maximize efficiency of operations in order to promote worker productivity, to shorten project time and to reduce cost. Second, the final plan must create a project with a good work environment in order to attract and retain the best personnel and thus contribute to better work quality and productivity.

The problem of site layout planning has been solved by researchers using two distinctly techniques: optimization and heuristics. Mathematical optimization procedures have been designed to produce the optimum solutions. The heuristic methods, on the other hand, used to produce good but not optimal solutions. However, the first category can not be adopted for large projects, and the second category is the only available mean for solving the complex real life projects.

2. The Problem

Failure to plan the site layout in advance is a prime cause of operational inefficiency, and can increase the overall cost of a project substantially. In the absence of a precise site layout plan, the following problems may occur:

a. *Material stacks wrongly located*. Materials arriving on site are off-loaded into what someone guesses to be the correct location. This problem may involve double or triple handling of materials to another location. For example:
   - They may stocked over a drainage line or near the edge of excavation;
   - They are too far from the work area;
   - They are too remote from the hoist or not within the radius of the crane;
   - They impede the smooth flow of work traffic across the site;
   - Their delivery was wrongly phased and they are not needed until much later in the project;
   - They are fragile.

b. *Plant and equipment wrongly located*. For example:
   - The mixer is inaccessible for the delivery of materials; not enough room for the storage of aggregates;
   - Fixed cranes are unable to reach all parts of the works;
   - Hoists have insufficient capacity or height to handle the loads or badly located in relation to the floor layout;

c. *Inadequate space allowed*. Where inadequate space is allowed for the stacking of materials or activities:
   - Materials may be stacked to high or stacked on roadways causing hazards.
   - Working areas may become too cramped or additional areas may have o be allocated with the consequent waste of time caused by having to travel between them.

d. *Site huts wrongly located in relation to their effective use*, such as:
   - Site office located too near noisy activities such as mixer, or located too near to site roads in dusty conditions, or too remote with insufficient overview of the site.

- Warehouses having inadequate access for loading and unloading or located in insecure area.

Therefore, before moving on to a site, it is necessary to prepare a detailed site plan, showing the positions to be taken by every item of equipment, accommodation, ancillary work areas and materials storage areas.

3. Present Practice

In construction, field practitioners manually mark up a single site drawing to include major temporary facilities needed on site throughout the duration of the project. They depend on knowledge of years of experience, common sense, and adoption of past layouts in determining positions of temporary facilities on site. But, they can not keep track of all factors that could affect the selection, location, and interactions of all facilities to be positioned.

In fact, site layout planning is one of the preplanning tasks to be accomplished in a construction project. This task has an interactive relationship with the other planning tasks such as scheduling, selection of construction method, procurement and material planning, manpower and equipment planning, and financial planning. So, it becomes a task as important as other tasks that project managers have to accomplish.

4. Site Layout Planning Elements

A well planned site including all temporary facilities and utilities lead to: 1) increasing productivity and safety, 2) reducing area(s) needed for temporary construction, and 3) maximizing utilization. The following points should be considered in good site layout.

1. Safety

- Fire prevention: Fire is a major cause of damage on construction sites. So that, fire extinguishers are basic requirements on a construction project.
- Medical services: On construction project a first aid kit is a must. In remote projects a well-equipped medical room with a doctor and nurse is important.
- Construction safety clothing: Basic safety supplies like safety shoes, hard hats, gloves, and goggles must be used by workers.

2. Site Accessibility

Easy accessibility will keep the morale of the equipment and vehicle drivers high, minimize the chance of accidents, and save time in maneuvering to arrive at and leave the project. In case of large projects, proper planning is required to layout the roads leading from the nearest highway. Internal roads are necessary for easy flow of work. Also, Parking Lots are provided for the owner, office, and craft personnel, but this facility must be planned where space does exist.

3. Information Signs

- Site map: It should locate details of the project, and displayed in the office of the site superintendent or project manager and posted at the entrance gate.
- Traffic regulatory signs: For large projects, traffic regulatory signs help in guiding the traffic on the site and avoid accidents to a considerable extent.
- Display of labor relations' policy and safety rules: This will help in eliminating disputes between labor and management.
- Emergency routes and underground services: It is important to display the emergency escape routes on every floor as the building progresses. Locations of underground services should be marked to prevent its damage.

4. Security

- Entrance: It is necessary to have a proper guard entrance to the site provided by a booth. Also, it is necessary to keep track of all visitors to the project.
- Lighting: It is necessary to have a standby generator to maintain site lighting.
- Fencing: The boundary should be fenced off from a security point of view.

5. Accommodation

On large construction projects, it is necessary to provide camp accommodation for all type of staff involved in the project.

6. Offices

The offices should be close together, close to the site, and in a safe area. Also, provide the offices with proper office equipment. The offices at the site may include job office, general contractor office, and sub-contractors and consultants Offices.

7. Water Supply and Sanitation

It is necessary to have water and toilet facilities in convenient locations to accommodate the work force.

8. Material Handling

One third or more of all construction operations can be classified as material handling. The use of proper equipment for material handling and advance planning for minimizing multiple handling will result in direct cost and time savings.

9. Storage and site cleaning

It is necessary to plan and reserve storage areas for materials so that multiple movement of material is avoided.

- Laydown areas: Areas reserved for storage of large materials and equipment and it can be short-term or long-term.
- Warehouses: They are sheltered storage facilities where materials are stored until they have disbursed to the job.
- Material staging areas: They used when materials are stored near the work on a short-term basis. They are generally as close to work as possible.
- Site cleaning: It is necessary at a work place and especially where the extent of debris produced is high. Regular disposal of debris is necessary.

10. Craft Change-Houses

Craft change-houses provide sheltered space for craft personnel to change and store clothes, wash, and rest during waiting periods.

11. Batch plant and Fabrication Shops

Batch plants are provided on projects where it is more economical to produce concrete on site than to buy a ready mix. Aggregate storage piles, cement silos and admixture tanks will accompany an on-site batch plant. Shops are used where materials and equipment are fabricated on site. This includes electrical, mechanical, carpentry, and paint shops. Also, testing shops used to house the necessary testing equipment and personnel for the project.

5. Temporary Facilities Characteristics

It is important to understand the characteristics of the temporary facilities before planning the site layout. Six generic temporary facility characteristics are discussed in this section.

1. Satisfying environmental and safety regulations: All temporary facilities should satisfy environmental and safety regulations. Special attention should be paid to temporary facilities like batch plants, which have high pollution potential. Planners have to make proper arrangements to control the air, water, and noise pollution from such facilities.

2. Availability of diverse solutions for the same problem: There are many arrangements that can be made to establish a temporary facility. For example, if a warehouse is required, the planner can build a warehouse on the site, use existing facilities on the site, rent a building near the site, or plan a just in time delivery. Based on the usage of the warehouses, each alternative can be further divided into several sub items. For example, the material of building the facility can vary from wood, bricks, to a steel structure.

3. Relatively short life span of a specific location: The life span of temporary facility depends on the duration of the project. In general, it must be removed as soon as the project is completed.

4. Reutilization with a minimum loss for the same or modified function at another location: Due to the shorter life span of temporary facility on site, planners consider reutilization of the temporary facilities. This can result in saving the cost of construction. With appropriate

modifications, most of the temporary facilities can be used for more different purposes. Therefore, good maintenance, and storage of the building materials can increase the frequency of reutilization and decrease construction costs significantly.

5. Easy of assembly, dismantling, and exploitation: temporary facilities structures which are easy to assemble and dismantle will reduce both assembly and disassembly time. As mentioned above, temporary facilities will need to be removed in a very short period of time after project completion. Thus, temporary facilities structures should be easy to assemble and dismantle without any damage to the structure components. Prefabricated modules are ideal for constructing temporary facilities and they are usually easy to assemble and dismantle.

6. Standardization of design: Standardization of design and construction of temporary facilities can increase the frequency of reutilization and reduce the work-hours and cost required for construction the facilities. This approach makes the maintenance, transportation and storage of temporary facilities easy. The benefits of the learning curve can be gained from repetitive field operations, which results in increase of productivity and quality. Also, benefits are obtained by providing grater interchangeability of spare parts and reducing the variety of spare parts stored in the warehouse.

6. Facility Identification and Sizing

Identifying the required temporary facilities for a specific project and determining their areas are difficult decisions that require thorough consideration of the project conditions and local regulations. In current practice, layout planning is often done in a speedy manner by adjusting previous plans based mainly on the project manager's experience and common sense. In many situations, some facilities, which are required by local by-laws, such as a site first-aid office or a fire route may be omitted. Accommodating these facilities later can be costly and can cause loss of site productivity. While some information related to facility identification and sizing have been documented in the literature, this information however is scattered and is not readily usable.

In order to develop the knowledge base for the facility identification and area determination, the knowledge were acquired and compiled from different sources, including construction safety and health manuals, company handbooks, published dissertations, technical articles, and interviews with some experts in the construction industry.

Temporary Facilities Selection

One of the characteristics of temporary facilities is the availability of diverse solutions for the same function. This section describes some of the considerations when selecting the required temporary facilities for a specific project.

- *Construction type*: The construction of an industrial plant, such as power plant, requires more storage and fabrication area for process mechanical and electrical work than other projects such as a highway project.

- *Type of contract*: For turn-key contract, the contractor can consolidate the administrative and construction operations, means that fewer but larger and more efficient temporary facilities can be selected. On the other hand, if the project is managed under a series of different contracts, this will translate into a higher number of smaller temporary facilities serving each individual contractor.

- *Project size*: A relatively small project can be managed from a trailer or portable structure. While a five to ten year project may need temporary facilities of a more permanent nature.

- *Project location*: Projects located in uninhabited regions or in places where skilled labor is scarce require additional facilities for eating and living. Project far from industrial centers require more on site services such as batch plant, equipment maintenance shops, long term storage area, and even some other recreational centers for the families.

Also, the selection of some of the temporary facilities depends on the manpower permanent resident from the site. The work force breaked down into three categories as shown in Figure 1:

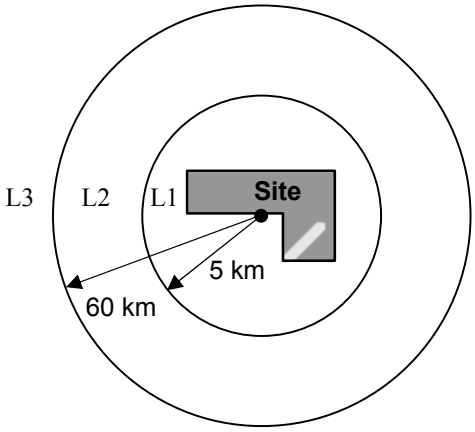

Figure 1: Work-force break-down

L1: local labor force (5 km from site). No lodging or transportation needs.
L2: nearby labor force (5 - 60 km from site). No lodging needs, but daily transportation needed.
L3: far away (more than 60 km from site). Lodging facilities needed.

The type and number of temporary facilities needed for a specific project must be determined prior to their sizing and location. Table 1 gives a list of common temporary facilities that can be used in a project. While some temporary facilities are to be selected from this list for a specific project, taking into account the factors cited above, as well as other temporary facilities justified by the uniqueness of the project.

Table 1: A List of temporary facilities

Facility No.	Facility Name
1	Job office
2	Owner representatives office
3	Subcontractors office
4	First aid office
5	Information and guard house
6	Toilet on site
7	Staff/Engineer dormitory
8	Staff/Engineer family dormitory
9	Labor dormitory
10	Labor family dormitory
11	Dinning room for labor
12	Bathroom for labor
13	Restroom for labor
14	Equipment maintenance shop
15	Parking lot for mechanics
16	Prefabricated rebar storage yard
17	Rebar fabrication yard
18	Fabricated rebar storage yard
19	Carpentry shop
20	Storage yard for lumber
21	Storage yard for formed lumber
22	Cement warehouse
23	Batch-plant and aggregate storage
24	Craft change-house
25	Sampling / Testing lab
26	Pipe jointing yard
27	Pipe storage yard
28	Welding shop
29	Parking lot
30	Tank
31	Long term laydown storage
32	Machine room
33	Electrical shop
34	Steel fabrication shop
35	Sandblast shop
36	Painting shop
37	Scaffold storage yard
38	Material warehouse

Temporary Facilities Sizing

After selecting the temporary facilities that are needed on the site, the size required for them must be estimated. The size of temporary facilities is mainly based on the manpower requirements, estimated quantity of work, production rate of resources, availability of site space, and cost considerations. Some of the rules of thumb, safety regulations, and other criteria for sizing temporary facilities are described below.

Rules of thumb of sizing temporary facilities

According to survey among 36 construction Company of various sizes, the size of temporary facilities are based on manpower requirements, project size, duration or costs. Ignoring the large variations of the numeric values, his rules show that the companies have similar practices. However, some adjustments have to be made when they are applied to a unique project. Tables 2, 3, and 4 illustrate the results of the survey. The values presented in Table 4 for projects ranges from $200 million to $4.5 billion, with average values around $2 billion.

Table 2: Area estimates for temporary facilities

Temporary Facility	**Minimum (m^2)**	**Average (m^2)**	**Maximum (m^2)**
- Craft change house per worker	0.09	1.02	2.7
- Time office per office worker	5.4	8.7	13.5
- Number of people per brass alley (with average area per person)	100 Person	175 Person 0.37	250 person
- Number of workers per parking space	1	1.7	4
- Area required for each unit parking	22.5	30	36

Table 3 Range of office space requirements

Office	**Size Range (m^2)**
- Project Manager	12 – 25
- Construction Manager	9 – 14
- Mechanical/ Electrical/ Civil Engineer per Engineer	9 – 11
- Purchasing (total)	46 – 84
- Schedule & Cost Control (total)	28 – 93
- Accounting (total)	37 – 80
- First Aid & Safety per Office	17 – 19
- Clerical (total)	28 – 74
- Estimator	11

The size of sanitary facilities depended on the manpower requirements and it can be entirely temporary or permanent. If portable toilets are used, a minimum of one toilet per twenty persons must be provided. Space required for some facilities as fabrication shops dependent on the amount of on-site fabrication work as well as rate of fabrication dictated by construction schedule. Also, the size of the equipment maintenance shop depends on the amount of construction equipment on the site.

Table 4: Temporary facilities areas based on project cost

Facility	**Area (m^2 / $ Million)**
Warehouse	2.80
Laydown Areas	28.9
Fabrication Shop	0.38
Equipment Shop	0.37
Administration office	1.11

Based on experience, the following general equation is used to determine the material storage area for any type of construction project. Table 5 shows the parameters that affect this equation. The total required storage area, A_n, is calculated as follows:

$$A_n = (Q_{max} / I_m) / q_n \quad (1)$$

Where: $Q_{max} = q_{daily} * t * k$, $q_{daily} = Q_{total} / T$

Q_{max} : Maximum estimated quantity in storage space;
I_m : Utilization index for materials;
q_n : quantity of materials can be stored per m^2;
Q_{total} : Total quantity of materials required for the project;
q_{daily} : estimated quantity required per day;
T : construction period (not total project duration);
t : Average stock (days); and
k : Fluctuation factor

Table 5: Parameters for sizing material storage area

Description	Delivery & Storage method	Unit	Average Stock t (days)	q_n quantity / m^2	I_m Utilization factor	Waste %
Cement	Bags	ton	30	1.5 - 1.8	0.5 - 0.6	1.5
	Bulk	ton	30	---	---	0.5
Aggregate for Concrete	Bulk	m^3	60	1.5 - 2.0	0.6 - 0.7	2.0
Bricks	Units	unit	30	700-1000	0.7 - 0.8	2 - 3
Concrete blocks	Pieces	unit	30	75 - 100	0.7 - 0.8	3-3.5
Lumber	Pieces	m^3	45	1.7 - 2.6	0.6 - 0.7	2-3
Reinforcing bars	Bars	ton	75	1.3 -1.5	0.75 - 0.8	1-1.2
Concrete pipes	Pieces	ton	30	0.8 - 1.1	0.6 - 0.7	1.0
Iron pipes	Pieces	ton	75	0.6 - 1.5	0.6 - 0.7	0.5
Fuel	Barrels	ton	30	0.5 - 0.7	0.7 - 0.8	1.0

Table 6 shows the rules of thumb developed by Obayashi Corporation of Japan. The areas given in Table 6 are based on the following assumptions:

- For each facility, the unit area includes areas for corridors, closets and aisles.
- The area of the bathroom should be adequate for simultaneous use by 10% of the residents, and one toilet for 15 labors.
- The number of labors is the peak number of labors required.

Table 6: Equations to calculate temporary facilities size

Description	Equations for Calculations		
	Variable	Unit	Use Rate%
1. Job office	peak number of Staff/Eng.	80.73 sf**/pp	70
2. Dormitory for Staff / Eng.	variable 1 - variable 3	86.11 sf/pp	80
3. Dormitory for Staff / Eng. Family	number of Staff/Eng. With family	322.92 sf/pp	-
4. Dormitory for labor	peak number of labors	48.44 sf/pp***	75
5. Dormitory for labor family	peak number of labors with family	269.1 sf/pp	-
6. Bathroom for Staff / Eng.	variable 2 x Use Rate	43.06 sf/pp	20
7. Bathroom for staff / Eng. Family	variable 3	21.53 sf/pp	-
8. Toilet (job office)	variable 1 x Use Rate	32.29 sf/pp	10
9. Toilet (staff / Eng. Dormitory)	variable 2 x Use Rate	32.29 sf/pp	10
10. Dining room for labor	variable 4 x Use Rate - variable 5	21.53 sf/pp	60
11. Bathroom for labor	variable 4 x Use Rate	32.29 sf/pp	10
12. Toilet for labor Dormitory	variable 4 x Use Rate	26.91 sf/pp	10
13. Parking lot	number of cars	215.28 sf/car	-
14. Canteen	variable 1 x (1 – Use Rate)	64.58 sf/pp	80
15. Owner's representative office	the number of representatives	86.11 sf/pp	-
16. Toilet on site	variables (14 + 15 + 17) / 15	32.29 sf/toilet	-
17. Rest area for labor	variable 4	16.15 sf/pp	30
18. Equipment maintenance shop	number of mechanicians	322.92 sf/pp	-
19. Parking lot for mechanician	number of mechanicians	322.92 sf/pp	-
20. Material warehouse	project cost	150-266 sf/m*	-
21. Rebar fabrication yard	peak number of iron workers	75.35 sf/pp	-
22. Rebar storage yard (prefab.)	(peak number of usage/day)x days	16.15 sf/ton	-
23. Rebar storage yard (straight)	(peak number of usage/day)x days	10.76 sf/ton	-
24. Carpentry shop	peak number of carpenters	53.82 sf/pp	-
25. Form storage yard	(peak number of usage/day)x days	0.72 sf	-
26. Cement warehouse	(peak number of usage/day)x days	0.36 sf/pack	-
27. Explosive warehouse	maximum storage 3t	80.73 0sf	-
	5t	107.64 sf	-
	10t	161.46 sf	-
28. Detonator warehouse	maximum storage 3t	37.670 sf	-
	5t	53.820 sf	-
	10t	80.730 sf	-
29. Explosive treatment shop		32.29-64.58 sf	-
30. subcontractor office		269 - 398.3 sf	-
31. Information office		484.4-645.8 sf	-
32. Test laboratory		319.2-538.2 sf	-
33. First aid		215.3-322.9 sf	-
34. machine room	Area needed for the machines	4 - 5 times	-
35. Site area	Building area	2 - 4 times	-

***m:** million ****sf:** square feet *****pp:** per person

7. Regulations and Safety Standards

Some safety rules were also compiled from safety and health manual (ILO 1992), safety and health administration (OSHA 1987), building codes (UBC 1985; SBC 1985). Some of these regulations are listed below.

- At least 10 feet clearance from buildings or structures shall be maintained for piles of lumber and other combustible materials to be used in the construction.
- Driveways between and around open yard combustible storage piles shall be at least 15 feet wide and free from accumulation of rubbish.
- Material stored inside buildings under construction shall not be placed within 6 feet of any hoist way or inside floor openings, or within 10 feet of an exterior wall, which does not extend above the top of the material stored.

8. Examples of Site Layout Planning

Example 1

Figure 2 illustrates the layout of building materials and access roads for the purposes of servicing two hoists for the erection of a low-rise building. Comment on and criticize the present layout in relation to the positioning of both the materials and hoists.

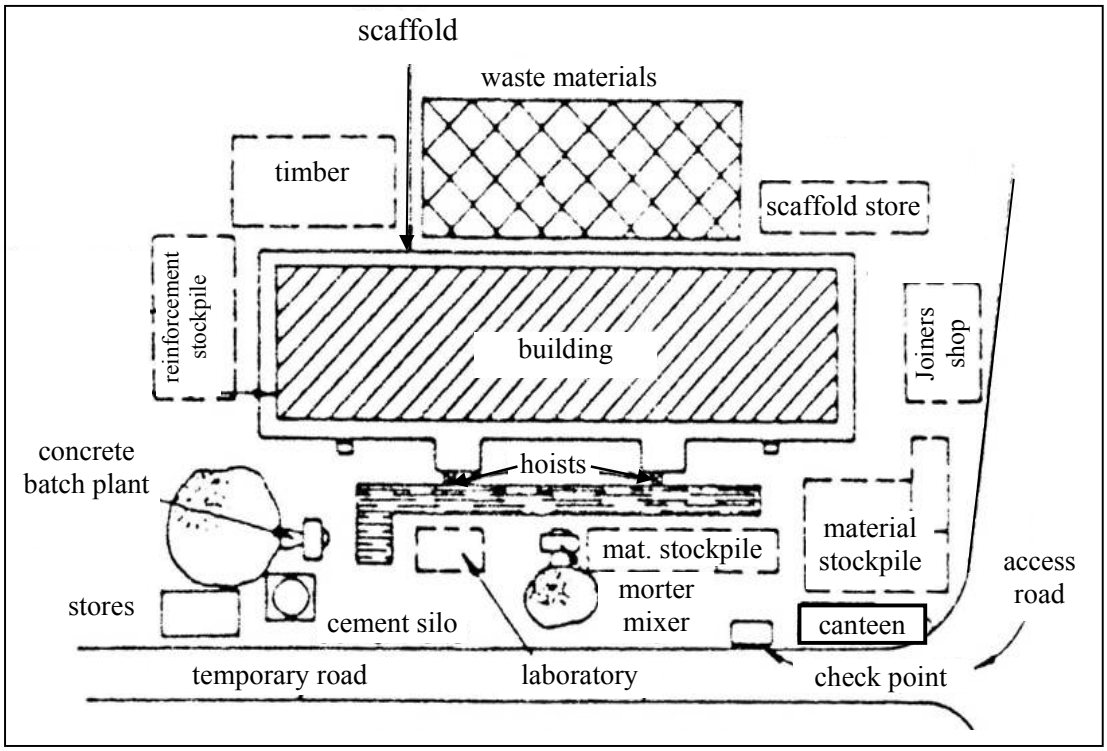

Figure 2: Existing site layout

Criticism of existing site layout:

- Both hoists have separate scaffold staging, causing increased costs.
- Materials are not stockpiled near hoists.
- Entrance to the site is too narrow for truck to pass.

- Stores are located behind the batching plant so obscuring storeman's view and check point is separated from the stores.
- Concrete and mortar mixers are located too far from the hoists.
- Stockpiles are dispersed and hinder unloading.
- Temporary roads are long and narrow.
- Some stores are difficult to reach.

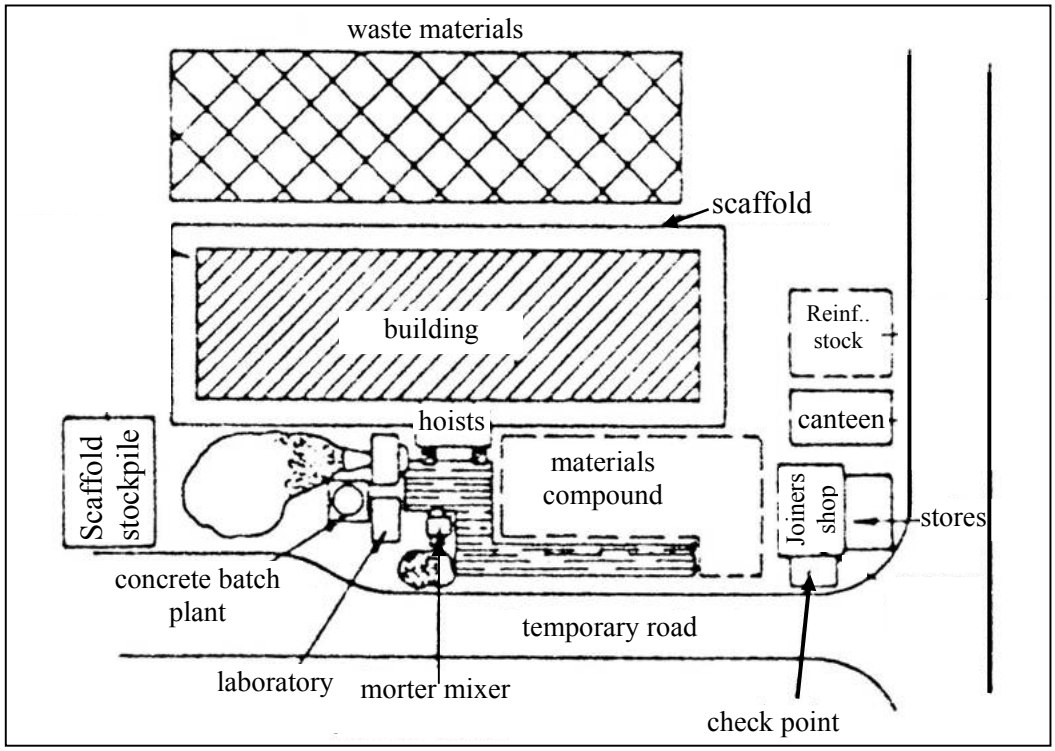

Figure 3: Improved site layout

Suggested improved layout:

- Both hoists are housed in a common scaffold.
- Batching plants have direct discharge into dumpers.
- The access has been widened near the site entrance.
- The stores are located to give a good view of all materials stockpiles, and are sited near the temporary road.
- Concrete and mortar mixers are located near the hoists.
- The temporary road is shorter and wider.
- A compound is provided to police non-bulk materials.

Example 2

Figure 4 shows the construction site for the construction of a radio transmitter station on a remote site in open location. The site involves the construction of a transmitting tower and transmitter building along with some access roads.

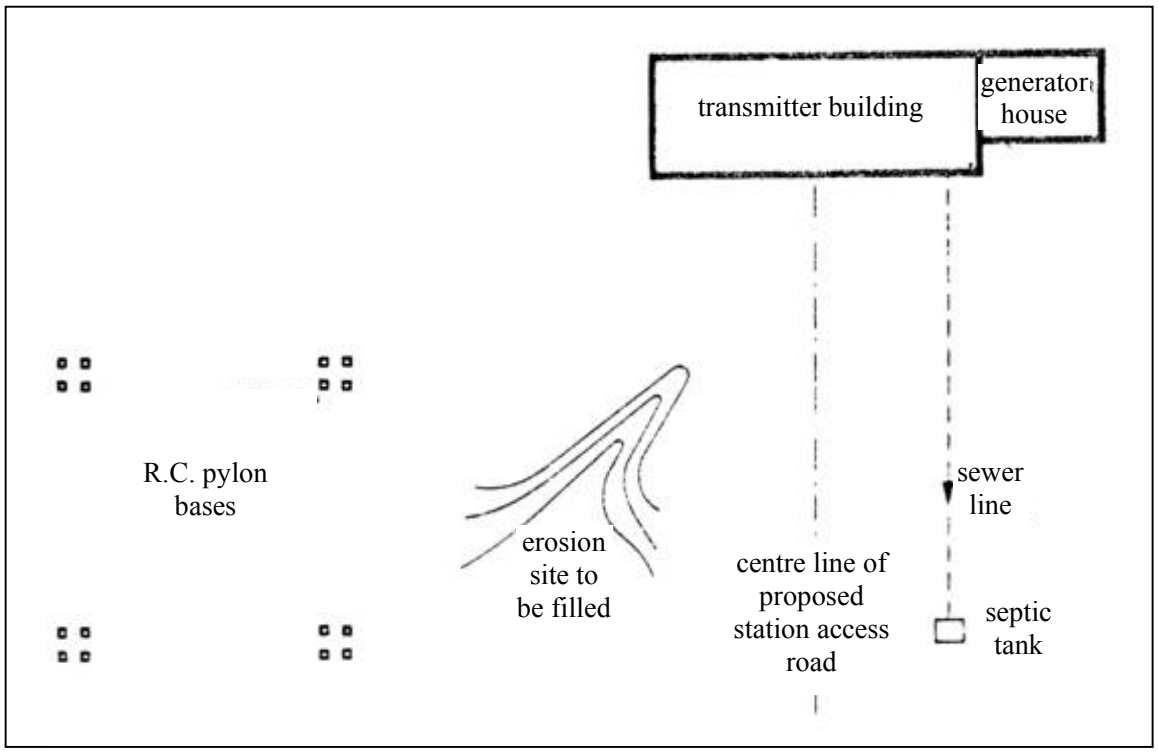

Figure 4: Transmitter station construction site

The contractor prepared the site layout plan as shown in Figure 5. In developing this given plan, the contractor collected the following information to layout the site:

- All equipment was delivered before building foundations were complete. All other fitting also delivered (doors, sanitary, etc.).
- Generator house completed. Hoist was not available at commencement and has only just delivered.
- Nearest pure water is in the town 20-km away. Water delivered by tanker and stored in 6 200-litre drums.
- Pylon bases and sewer/septic tank not yet started.
- Agents' office is sited on a privileged place and to satisfy the best view for site.

Criticize the layout given in Figure 5 and prepare another layout to correct the criticism.

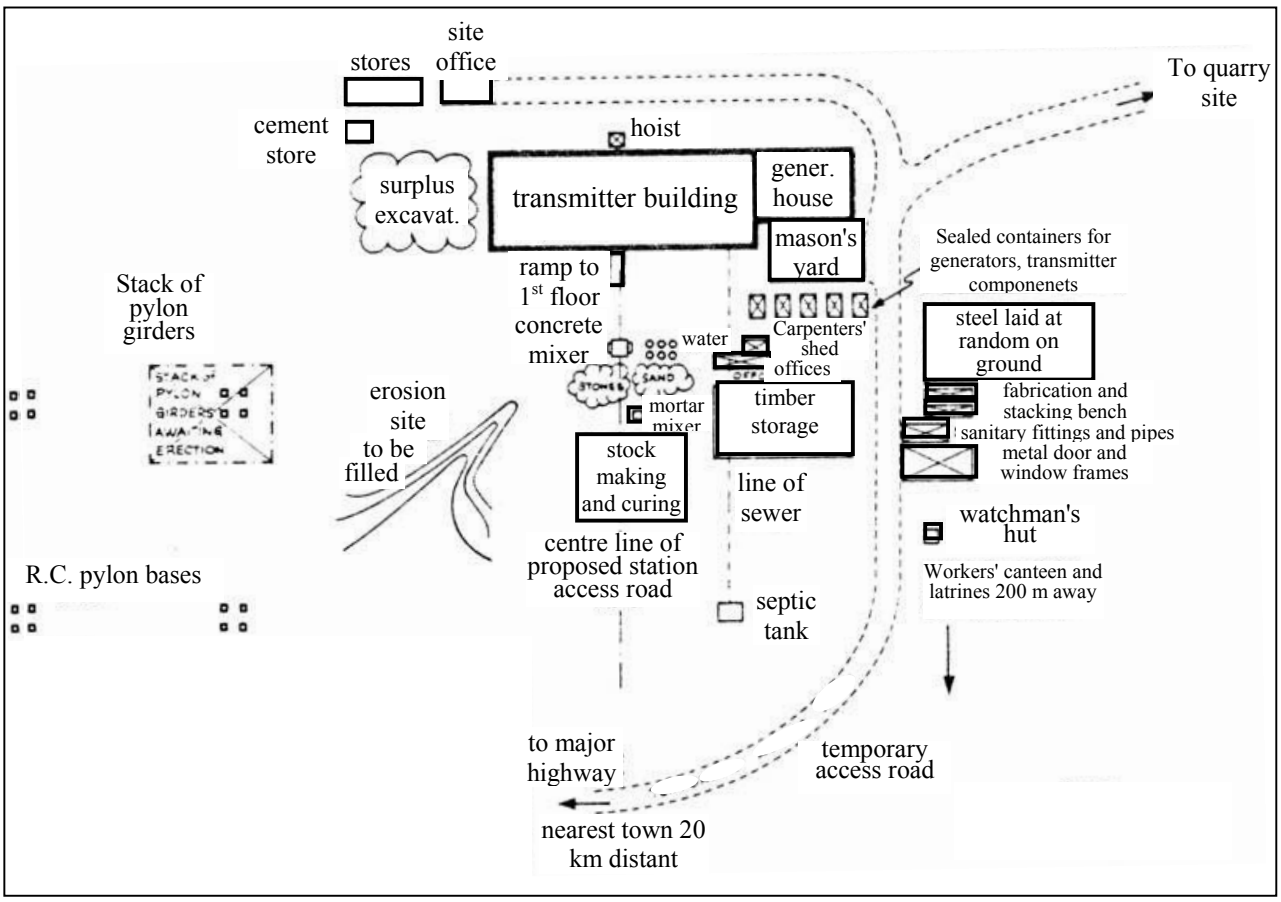

Figure 5: Existing site layout

Criticism of existing site layout

- In general, the working area is too spread out, making control more difficult and increasing travelling time about the site which will lead to reducing productivity.
- Site latrines and canteen are too far away, causing loss of time due to unnecessary travelling. There is no apparent supply of drinking water on site.
- No security fencing is shown.
- Temporary access road should follow the line of the proposed station access road to avoid duplication of work.
- Surplus excavation should have been led directly to the erosion site to avoid double handling.
- Pylon girders have been stacked over foundation bases, necessitating double handling.

- Stonemason's yard interferes with the movement and handling of technical equipment from the sealed containers.
- Site office is wrongly located. As the building rises the view of the site will be blocked.
- Cement store is too far from the mixer.
- Hoist is on the wrong the side of the building, too far from the work areas.
- Mortar-mixing and block-making areas are too far from the building.
- Temporary buildings and storage areas are sited over the line of the sewer. The sewer should be constructed early to free the ground.
- Steel is laid on the ground and not stacked in an orderly manner. Bending and fabrication benches are wrongly placed.
- Timber storage area is unorganized.
- Sanitary fittings, pipes, and frames are stacked too near to the access road violating safety.

Suggested improved layout:

Figure 6 shows the suggested improved site layout planning to offset the drawbacks recorded from the previous site plan given in Figure 5.

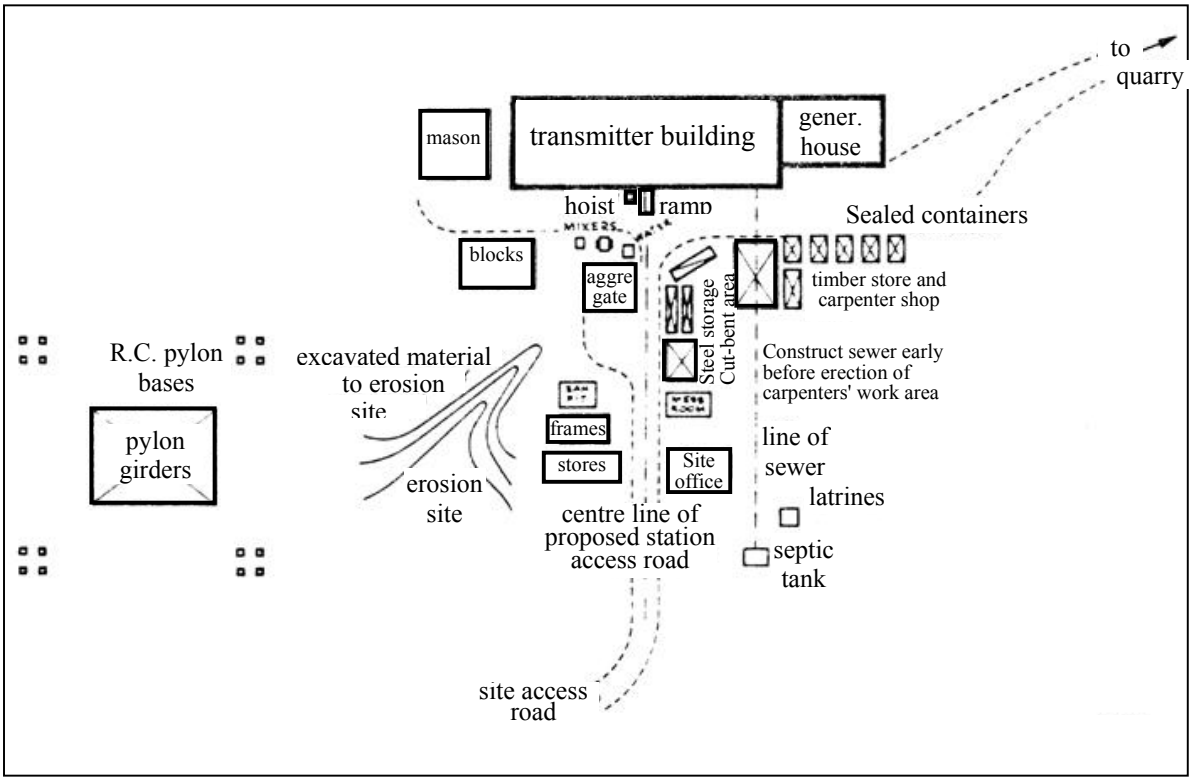

Figure 6: Improved site layout

9. Exercise

The project shown in the following figure is for the construction of water treatment plant located at Elmansoura City on the east bank of the Nile River (Domiatte branch) near Mansoura University. Access to the site is provided by an adjacent road, which joins the project site with the nearby highways. The project involves the construction of reservoirs and basins needed for the treatment operations and an operation building. The construction site area is about 53,000 m^2 (13 acre). The following figure shows the general layout plan of the construction site of the project prepared by the contractor. Comment and criticize the given layout.

10. References

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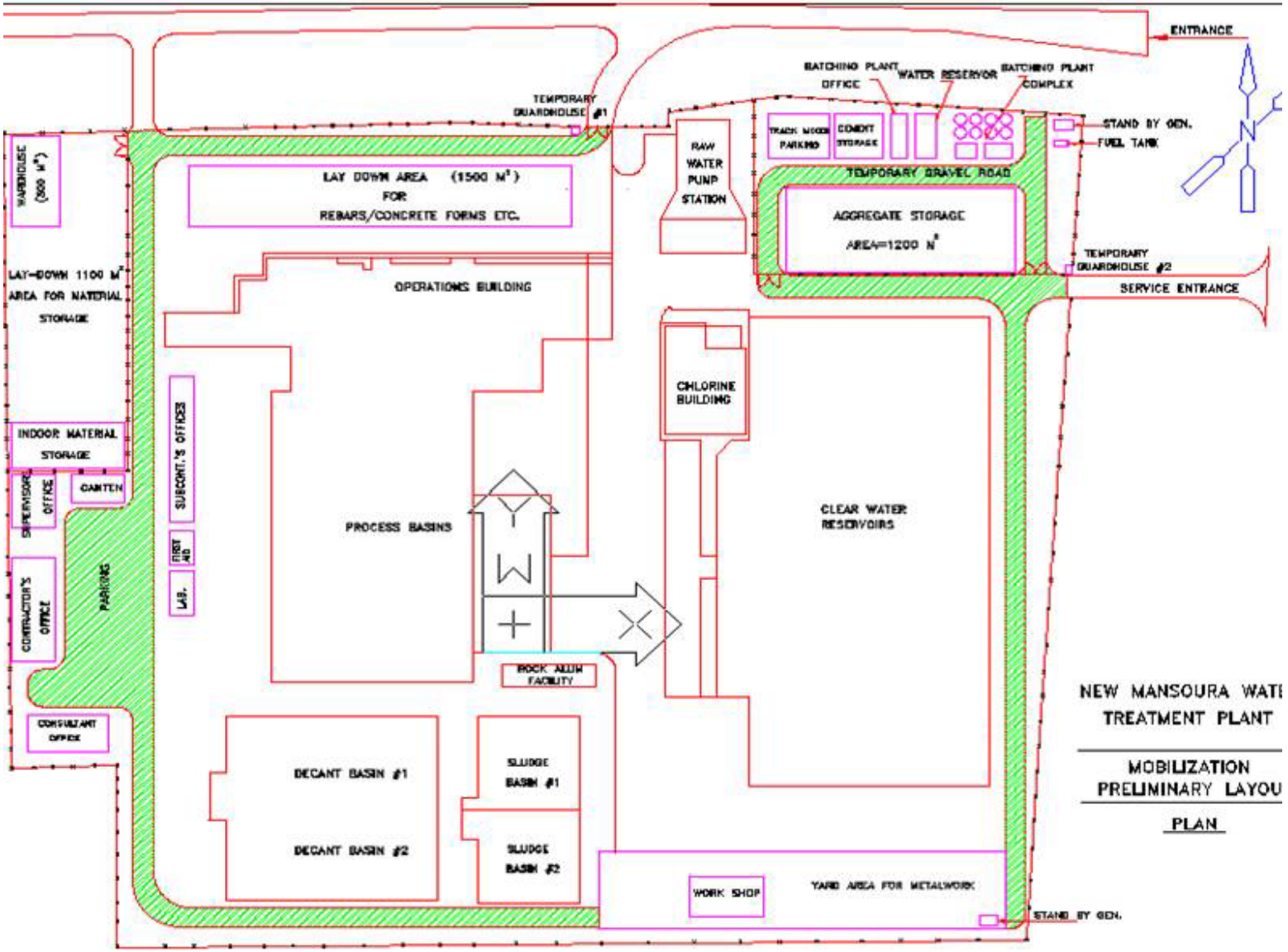
ENTRANCE
BATCHING PLANT OFFICE
WATER RESERVOIR
BATCHING PLANT COMPLEX
TEMPORARY GUARDHOUSE #1
STAND BY GEN.
FUEL TANK
WAREHOUSE (300 M²)
LAY DOWN AREA (1500 M²) FOR REBARS/CONCRETE FORMS ETC.
RAW WATER PUMP STATION
TRUCK MIXER PARKING
CEMENT STORAGE
TEMPORARY GRAVEL ROAD
AGGREGATE STORAGE AREA=1200 M²
LAY-DOWN 1100 M² AREA FOR MATERIAL STORAGE
OPERATIONS BUILDING
TEMPORARY GUARDHOUSE #2
SERVICE ENTRANCE
CHLORINE BUILDING
INDOOR MATERIAL STORAGE
SUBCONT.'S OFFICES
FIRST AID
LAB.
SUPERVISOR OFFICE
CANTEN
PROCESS BASINS
CLEAR WATER RESERVOIRS
CONTRACTOR'S OFFICE
PARKING
ROCK ALUM FACILITY
CONSULTANT OFFICE
DECANT BASIN #1
DECANT BASIN #2
SLUDGE BASIN #1
SLUDGE BASIN #2
WORK SHOP
YARD AREA FOR METALWORK
STAND BY GEN.
N
NEW MANSOURA WATE
TREATMENT PLANT
MOBILIZATION
PRELIMINARY LAYOU
PLAN