Window and Glazing Topics – Factory layout workbook

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Part 1: Introduction

1. General

Factory layout problems confront every manufacturing concern at some time during its life. It may be that changes in product design or production processes give a revised sequence of operations or requires a totally new set of operations. The result of these factors is that the need for more or less space is generated, or the flow of work from one area to another leaves something to be desired. There are also situations in which new products are introduced, existing items are deleted, or the required level of output changes. Finally, the company may find that its overall factory layout is such that work in progress is excessive due to the inefficient flow of work or that a space shortage exists because the available floor space is not being used effectively. The object of planning and laying out a factory is to achieve maximum productivity from the available machinery and space and, if necessary, defining the need to increase investment in either of these. Productivity is a topic which is all important in today's competitive world and is a combination of both factory effectiveness and labour effectiveness. It is important to note that we use effectiveness (doing the right things) rather than efficiency (doing things right) because you can be efficient even if you are doing something that is unimportant. Real productivity only comes from effectiveness.

Factory layout is both a balancing act and an art and this brief document can only deal with general procedures, the factors which should be taken into consideration, the manner in which these factors will affect the layout and provide some examples of specific layouts.

These notes need to be made specific to the level of operations to be considered and the space available. Whilst all due care and attention will be taken to produce the best and most effective factory layout, we cannot accept responsibility for compliance with the Factories Act and any other relevant statutory regulations. Compliance with these remains the responsibility of the fabricator.

2. Fundamentals for Factory Layout

There are certain criteria which must be satisfied by a good layout and these are:

Flexibility - A good layout will be able to be rapidly modified to meet changing circumstances. This is particularly relevant with the positioning of air-lines and electrical wiring. When a new layout is being carried out it is very easy to install redundant air-lines and electricity supply points. These can then be used to improve the flexibility of the layout at a later stage.

Co-ordination - A layout needs to be considered as a whole and not as a series of individual departments. Materials leaving a department should be in such a condition as to be convenient for the receiving department.

Use of Volume - In many cases a factory layout is considered as two dimensional, in actual fact a factory has a height dimension as well. Maximum use should be made of the volume available: conveyors can be run above head height and used as moving WIP stores, or tools and equipment can be suspended from the ceiling.

Visibility - All men and materials should be readily observable at all times: there should be no ‘hiding places’ into which goods can be mislaid. Every piece of partitioning or screening to form offices, stores and cupboards should be scrutinised as these introduce undesirable segregation and reduce effective floor space.

Accessibility - All service and maintenance points should be readily accessible. This applies not only to the machine service points but also to factory maintenance points.

Minimum distance - All movements should be both necessary and direct. Transportation adds to the cost of the product but does not add value, any unnecessary or circuitous movements should be avoided. Temporary storage places used whilst waiting for the next operation provide areas for work-in-progress (WIP) to build up and for suspect goods to be abandoned. The provision of any extra shelves, benches and tables should be avoided if at all possible.

Minimum Handling - When handling is unavoidable it should be mechanised, if possible, by the use of conveyors or other transportation equipment. Where possible material flow should be restricted by mechanisation so that no deviation from the planned path is possible.

Safety - All layouts should be inherently safe, and no person should be exposed to danger. The layout should bear in mind not only the operator of the machine but also other traffic and possible safety hazards.

Uni-directional flow - Work lanes and transport lanes should not cross. At every point in a factory material flow should be in one direction only. A layout which does not conform to this will result in considerable difficulties.

Visible Routes - Definite lines of travel should be provided and, if possible, clearly marked. No gangways should ever be used for storage purposes, even temporarily.

3. Advantages of a Good Layout

A layout meeting the fundamentals outlined above will have the following advantages:

- • The overall process time and cost will be minimised by reducing unnecessary handling and by generally increasing the effectiveness of all work.
- • Labour supervision and production control will be simplified by the elimination of hidden corners in which both men and material can be misplaced.
- • Changes in programme will be most readily accommodated.
- • Total output from the given plant will be as high as possible by making the maximum effective use of available space.
- • Product quality will be sustained by safer and better methods of production.

Every factory and building has its own problems and requirements. Rather than give specific recommendations we have given checklists for each individual area. These should be used to evaluate your operations at each stage.

Never forget that the Health and Safety of workers is affected by the factory layout. Clean and efficient factories are also safe factories!

The layout of a factory determines how effectively a factory will run. Without a good layout, operations in a factory will always be chaotic and production will be inefficient.

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Part 2: Individual areas

Every factory and building has its own problems and requirements. Rather than give specific recommendations we have given checklists for each individual area. These should be used to evaluate your operations at each stage.

1. New Premises/Relocation

The majority of businesses can be effectively relocated to new premises or a new area provided sufficient planning is made at the initial stages. The disruptive effects may take some time to disappear and should be planned for in advance. When considering a move it is essential that planning is carried out in advance, proper co-ordination and control is implemented and that future growth is taken into consideration.

Planning for the move must include the following:

- Process layouts and flow process charts.
- A detailed review of production equipment and any new equipment requirements.
- A re-examination of machine capacities.
- A detailed review of materials handling and stores requirements.
- Production of detailed factory layouts which consider materials flow, site access, services, noisy and dirty processes and personnel movement.
- Production of schedules should be laid down for new and existing plant.
- Firm ordering and delivery dates for any new machinery or equipment.
- A project plan for all of the above.

It is essential that financial analysis of the project is carried out at an early stage and during the planning stages.

New Premises

A move to a new or extended premises needs to be planned very carefully to avoid disruption of production. It may be possible to move in phases or try the "big week-end move" where it all happens at once. As a general rule the big move is less painful in the long run and we would recommend it. Either way it is essential that careful planning is done before the move and that you examine your existing layout critically to ensure that the move is really necessary. A revised layout can often free up a substantial amount of space or give increased production from the same space.

Relocation

As a general rule there are few substantial cost savings to be made as a result of relocation, even if an area of cheaper labour is chosen. It should be borne in mind that labour costs represent a relatively small percentage of the total cost of an item and even dramatic reductions in labour costs may not affect the total manufactured cost significantly. Increased transportation costs may well be greater than savings made as a result of direct labour cost reductions. The following factors should be taken into account:

- Reduction of transport costs.
- Availability of labour.
- Prestige of location.
- Transport links.
- Local competition/loss of current local market.
- Availability of specialist services.
- Site availability.

- Growth of business.

2. Factory Areas

Incoming Goods/Stores Areas/Despatch

1. Do these areas meet the requirements of the Factories Act and the Offices and Shops Act in terms of lighting, access and manual lifting?

2. What are the positions and clearances of doors, electric points, switches, fuse boxes, columns, beams, pipework, sprinklers and inspection covers?

Goods Inwards

1. How do goods come in?

2. What implications has this on: equipment? labour? handling?

3. Are areas provided for incoming goods and unpacking?

4. Have you checked floor loading capacity?

5. Have you allowed for storage of heavy items near to access points?

Stock Control

1. What system do you have for: stock recording? stock reordering? stock levels?

2. Do you use first in - first out storage?

3. Do you have capacity for buffer stocks?

Office/Recording

1. Is there a stores office provided?

2. Who is responsible for tidiness, stock reordering, safety?

3. Who is responsible for general supervision?

Despatch

1. Is there an area available for packing and despatch?

2. What handling equipment is used?

3. How many loading points are required and are available?

4. How big are the doors?

5. What draught proofing/screening is required?

6. Are deck levels adjustable (do they need to be)?

7. What vehicles are used for delivery and internal transport?

8. Does it need to be temperature controlled?

Inspection Areas and "HOLD" areas

Inspection Areas

1. Can gauges/equipment be safely and securely stored?

2. Are comparison samples safely stored?

3. Is there sufficient light?

4. Is there filing space?

5. Is there a clean area for report writing etc.?

"HOLD" Areas

A "HOLD" area is a defined area where goods subject to quality queries are stored. It is not used for

general production flow and is not a general storage area. Articles in the "HOLD" area must be cleared by the Quality Department before use.

1. Do you have a "HOLD" area?

2. Do you need more than one "HOLD" area?

Production Areas Safety and Related

1. Do these areas meet the requirements of the Factories Act and the Shops and Offices Act in terms of lighting, access and manual lifting?

2. Are machines adequately guarded?

3. Are gangways kept clear?

4. Do machines or goods on machines protrude into gangways?

Electricity

1. What is the likely electricity demand?

2. Can your existing connections cope?

3. Where do you have 3 phase?

4. Where do you need it?

Compressed Air

1. What is the likely compressed air demand?

2. Can your existing compressor cope?

3. Can an accumulator help with peak demand?

4. Where do you have outlets?

5. Where do you need them?

6. Are you losing air at any point?

7. Do you need filters?

8. Can the compressor be located away from main building (to reduce noise)?

9. Is it sound insulated?

10. Is it secure?

Water/Heating

1. Do you need a water supply?

2. Where?

3. How much hot water is needed?

4. Can the boiler cope?

5. What is comfortable working temperature range?

6. Can heating/cooling keep temperature within this range?

7. Do you need boosters/coolers to cover peaks and troughs of temperature range?

8. Can you insulate to save energy?

Telephones

1. How many telephones do you need?

2. Where do you need them?

3. Can your existing system/switchboard cope?

Lighting

1. What lighting levels are needed for various areas?

2. Is daylight sufficient?

3. Where do you need additional lighting?

Tool Storage

1. Are tool storage areas located near machines?

2. Is tool storage safe and secure?

3. Is there provision for personal tool storage?

Production Flow

1. What is the total distance travelled by a finished article?

2. Can this be reduced?

3. Is there sufficient (but not too much) space for work-in-progress (WIP)?

NOTE Too much space encourages WIP build-up and capital is tied up. Not enough space can lead to transient bottlenecks.

4. Is the production flow in one direction at all times?

NOTE: If product flow is such that it is not unidirectional then processed and unprocessed goods will be mixed and mistakes will be made.

The production area itself is vitally important in factory layout and an improved layout can reduce the need for space increases or new machine purchases.

Effective flow of product throughout the factory will lead to the following:

- Work-in-progress will decrease.
- Lead times will decrease.
- Cash flow will improve.
- Quality will improve

There is often a temptation to invest in machinery as a method of improving production flow but it should be remembered that this can simply move a bottleneck from one area of the factory to another. When faced with any machinery decision the question ‘how does this machine improve completed jobs out the door?’ must be answered.

Manpower savings are often quoted but these can be an illusion and, in most cases, labour represents a small proportion of the total product cost.

Investment is only justified if actual goods available for sale are increased or if lead times are decreased. To illustrate this, examine your last three major equipment purchases in the light of 4 simple questions:

- How much extra out-of-the-door product did this machine produce?
- How much did the labour force decrease after introducing the machine?
- How much did lead times decrease as a result of introducing the machine?
- How much did you reduce your stock by introducing the machine?

If the answers to these questions are not exceptionally positive then the value of purchasing the machine must be seriously questioned.

3. Service Areas

The desire for improved layout and effectiveness should not stop at the easily quantifiable areas such as production. Layout and environmental improvements in the service areas, e.g., offices, canteens, rest rooms and stores, can often provide low cost but drastic improvements in staff efficiency and morale. The condition of service areas is an indirect incentive (as opposed to direct incentives such as bonuses) and can be vitally important in motivating staff and reducing costly staff turnover.

Tangram Technology is not normally involved with service area layout and the following points are for guidance only.

Offices

Overall Layout/area

1. Is there a large proportion of unusable space e.g., stairs, corridors?

2. Is it big enough?

3. Is access good?

4. What is the area supposed to do?

5. Who needs to talk with each other?

6. How does work flow in the office?

7. Is there a place for meetings or discussion area?

8. Do you need one?

9. Are your communications such as mail, faxes and telephone calls getting through to the right people (and quickly)?

10. Is filing (and document retrieval) efficient and are space and facilities efficient?

Office Environment

1. Is the lighting sufficient?

2. Is the temperature right?

3. Is it noisy? smelly? dusty?

4. Are there draughts?

5. Do you want individual offices, open plan, demountable partitioning?

6. What type of partitioning would be most suitable, i.e., full height, barrier height?

7.What corridor/walkway width do you need and is there space for movement of people and goods?

Personnel Areas

1. How many people will be using the areas?

2. What are legal requirements for toilets and personnel facilities?

3. Do you have disabled facilities?

4. Are benches/seats to be provided?

5. Do you need locker areas for personal items?

6. How big should lockers be?

7. Who cleans these areas?

8. Who allocates lockers and is responsible for keys and replacements?

9. What security arrangements have been made?

Don't forget that modern factories and offices should have provision for computer networks and Internet access built into the fabric of the building. Installing computer networks is easy at the start but difficult when you are in the building.

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Part 3: Information for a factory layout

Prior to preparing a factory layout an information base needs to be gathered to ensure that the layout is appropriate. The basic information required is:

1. Basic Building

Overall dimensions of production area, office area, storage area and outside storage area.

Location of access and exit points for both products and personnel, including stairs (if applicable).

Location of stanchions or other building features which may affect layout, e.g., headroom.

Location and routing (where applicable) of services, e.g., windows, heating and boiler, compressed air lines and compressor, electricity, lighting and toilets.

2. Production Details

Number of frames per week (actual and planned)

Number of operators (actual and planned)

Approximate %'s of production mix for window types?

Casement	%
Tilt/Turn	%
Residoors	%
Other	%

Do you intend to manufacture conservatories?

Approximate %'s of production mix for customers?

Trade	%
Retail	%
Contracts/Local Authority	%

Are products supplied glazed or unglazed?

Are sealed units produced in-house or bought-in?

How is bead cutting and fitting carried out?

What storage areas are available and how are they fitted out, i.e., bins, racking etc.

Are the appropriate jigs available?

3. New Equipment

Is the layout to be with the existing equipment or is new equipment to be purchased?

What is proposed budget for equipment purchases?

Once this information is available a CAD generated layout of the proposed factory layout can be prepared for discussion with the relevant personnel.

Part 4: Typical factory layouts

1. General

Please note all layouts are based on mechanically jointed transoms/mullions. When considering welded transoms/mullions, provision for the appropriate machinery, i.e., 'V' notch saw, 'V' welder, and if required, a 'V' weld grooving machine, must be made.

Notes:

Machinery maintenance and repairs; most machinery companies offer service contracts and in the event of a breakdown, an engineer on site within a specified time scale. It may be worthwhile thinking in terms of simple machinery and tooling which can be more easily repaired by your own staff than more complex machinery that requires specialist technicians for repairs and maintenance.

Sharpening of cutting tools; again, machinery companies offer this facility. However, the turnaround time for this service may be too slow. In this instance, a competent local engineering company may be the answer.

Metal swarf should be kept away from PVC saws to avoid profile damage.

Operator levels are approximate only and do not include office staff.

2. 50 Windows/Week

1. Double head mitre saw.

2. End milling machine with cutter block, for mechanically joined transoms/mullions.

3. Copy router with guide plates for drainage and lock assemblies.

4. Single head welder with profile support blocks.

5. Corner cleaner hand held or bench mounted for removing surface weld sprue.

6. Bead saw with variable angle cutting.

7. Steel saw to cut reinforcing when required.

8. Work benches.

9. Toast racks for frame storage.

10. Compressor. The machinery company will advise on size required.

11. Other equipment, e.g., drills, screwdriver, sander, polisher, tilt and turn hand router and other general equipment.

- Factory Area - 160 m^2 approximately (Not to scale).
- Operators required: 3.

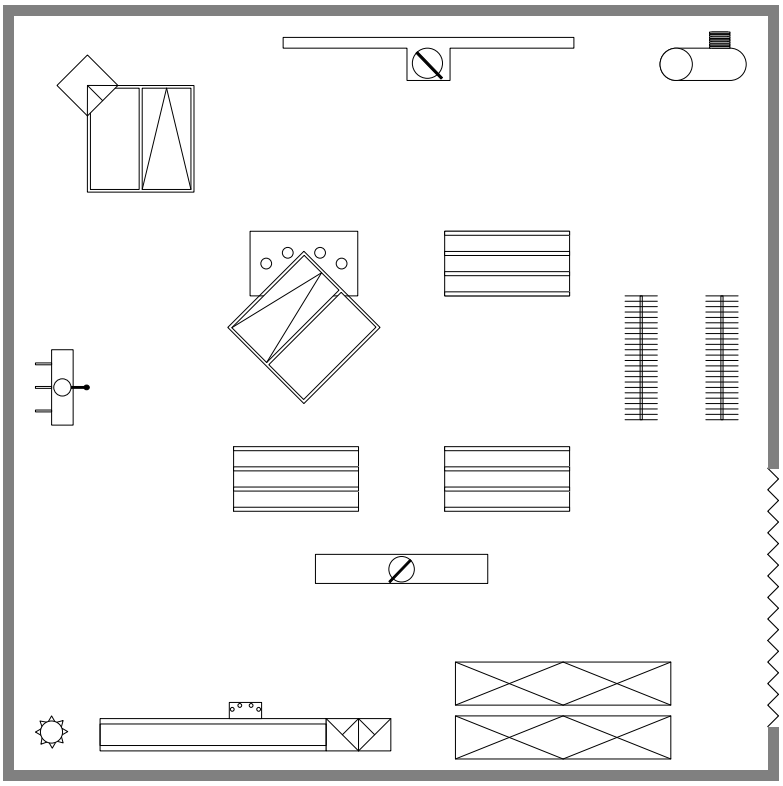

Figure 1: 50 Windows/Week

3. 100 Windows/Week

1. Double head mitre saw.

2. End milling machine with cutter block, for mechanically joined transoms/mullions.

3. Copy router with guide plates for drainage and lock assemblies.

4. Single head welder with profile support blocks.

5. Double head welder with profile support blocks.

6. Corner cleaner for surface weld sprue removal and two cutter blocks for removal of sprue on outer edge of casements.

7. Bead saw with variable angle cutting.

8. Steel saw for cutting reinforcing when required.

9. Work benches.

10. Toast racks for frame storage.

11. Compressor. The machinery company will advise on size required.

12. Other equipment, e.g., electric and pneumatic drills, screwdrivers, sander, polisher, tilt and turn hand router and other general equipment.

- Factory Area - 260 m^2 approximately (Not to scale).
- Operators required: 5 to 6.

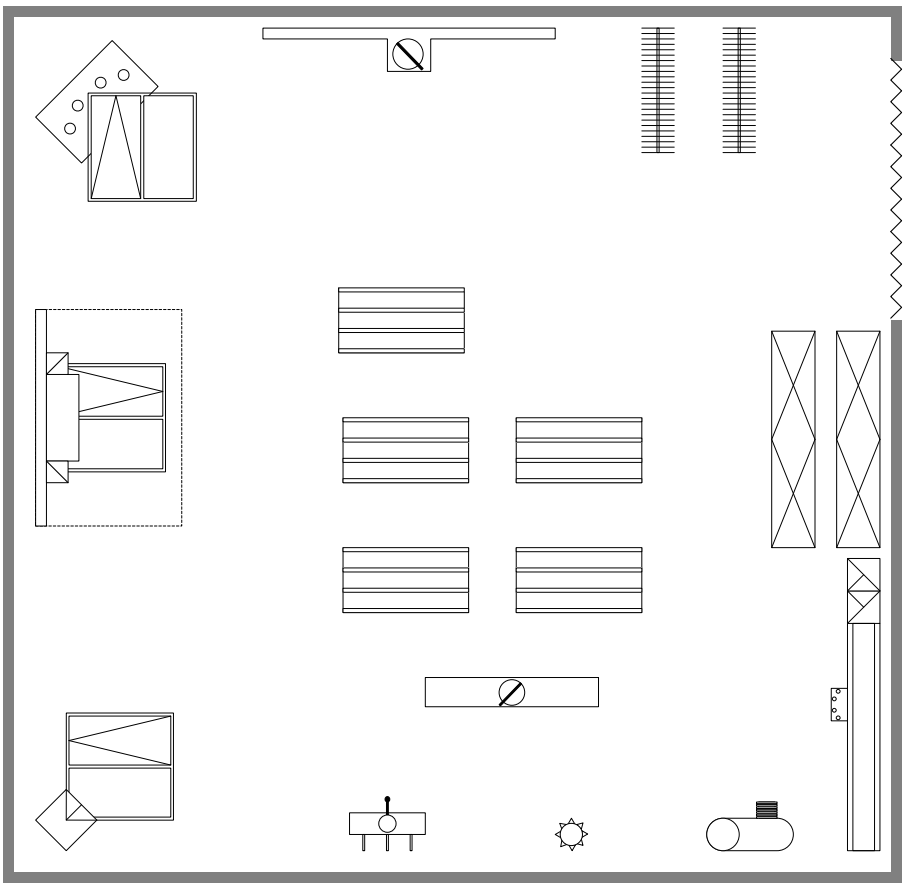

Figure 2: 100 Windows/Week

4. 150 Windows/Week

1. Double head mitre saw with electronic positioning.
2. End milling machine with cutter block for mechanically joined transoms/mullions.
3. Drainage router, triple head for face and concealed drainage.
4. Copy router with triple drill and guide plates for tilt and turn and lock assemblies.
5. Single head welder with profile support blocks.
6. Three head welder with profile support blocks.
7. Corner cleaner for all weld sprue removal on casements and outer frames.
8. Bead saws with variable angle cutting.
9. Steel saw for cutting reinforcing when required.
10. Work benches.
11. Toast racks for frame storage.
12. Reinforcing station for fixing reinforcing where required.
13. Profile trolleys to transport cut sections from work station to work station.
14. Compressor. The machinery company will advise on size required.
15. Other equipment, e.g., electric and pneumatic drills, screwdrivers, tilt and turn hand router, sizal brush, orbital sander and other general equipment.

- Factory Area - 260 m^2 approximately (Not to scale).
- Operators required: 6 to 8.

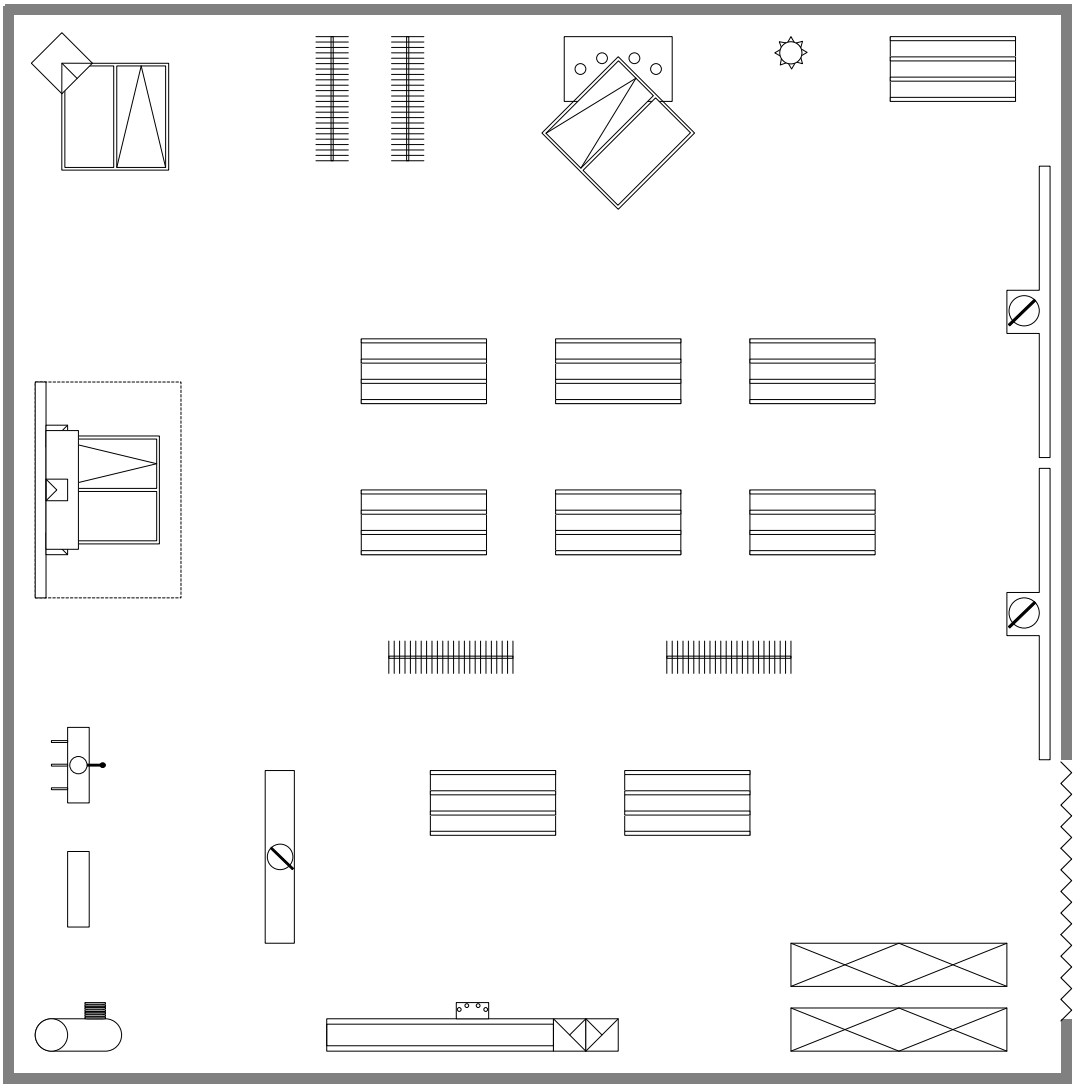

Figure 3: 150 Windows/Week

5. 200 Windows/Week

1. Profile main frame storage
2. Reinforcing rack.
3. Double head mitre saw with electronic positioning.
4. End miller with cutter blocks for mechanically joined transoms/mullions.
5. Drainage router, triple head for face and concealed drainage.
6. Copy router with triple head drill and guide plates for tilt and turn lock assemblies.
7. Single head welder with profile support blocks.
8. Three headed welder with profile support blocks.
9. Corner cleaner for all weld sprue removal on all casements and outer frames.
10. Bead saws with variable angle cutting.
11. Steel saw for cutting reinforcing when required.
12. Work benches.
13. Processing bench.
14. Toast racks for frame storage.
15. Reinforcing station for fixing reinforcing.
16. Profile trolleys for transportation of cut profile form work station to work station.
17. Compressor. The machinery company will advise on size required.
18. Other equipment, e.g., electric and pneumatic drills, screwdrivers, tilt and turn router, sizal brush, orbital sander and other hand tools.

- Factory Area - 308 m^2 approximately (Not to scale).
- Operators required: 10 to 12.

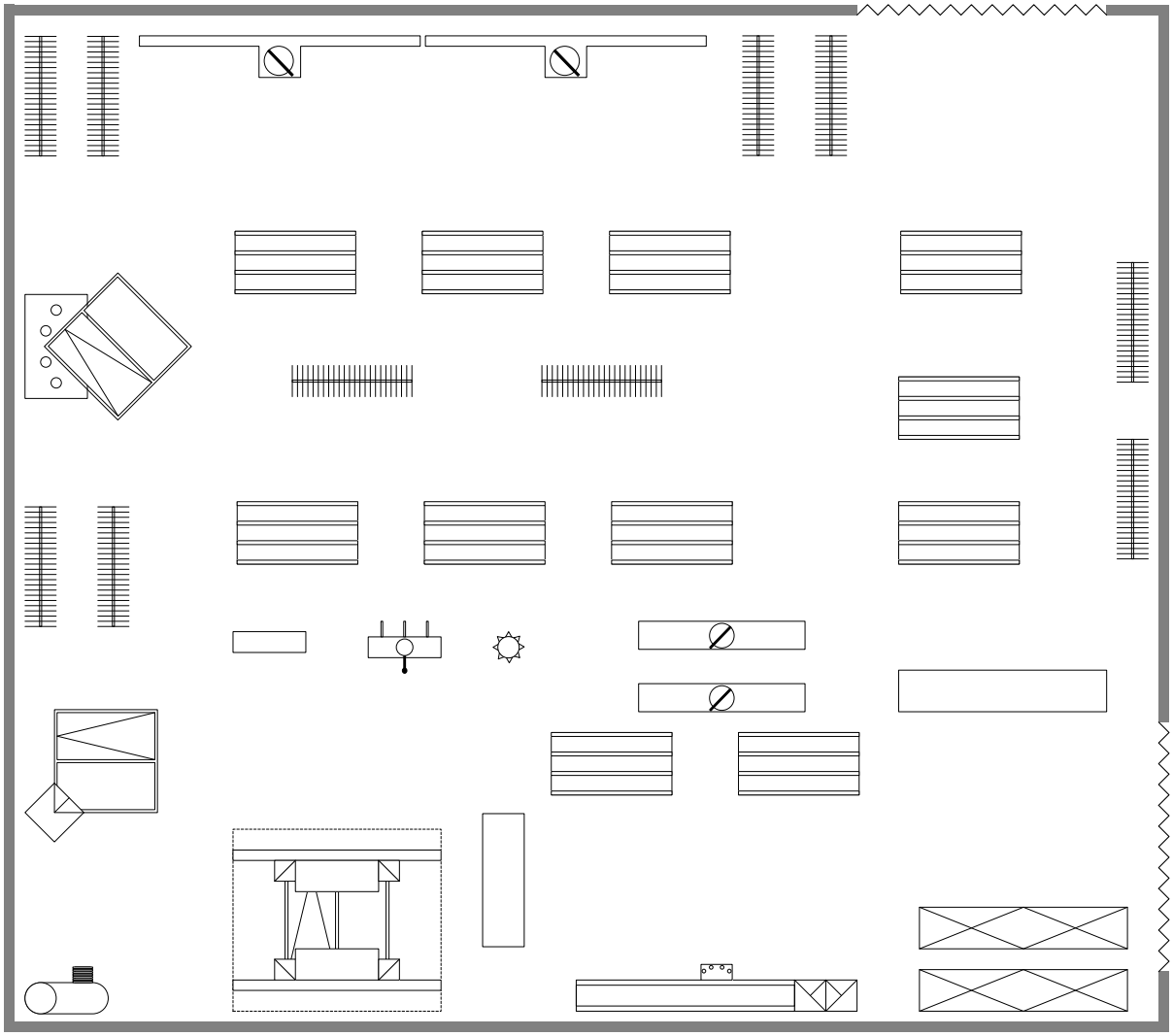

Figure 4: 200 Windows/Week

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Part 5: Flow process charts and analysis

Flow process charting is simply a way of putting on paper the sequence of operations and trying to improve the efficiency of these operations. Those familiar with Work Study will no doubt have come across them before. The method analyses the sequence of operations, transportations, delays, and storages occurring during a process or procedure, and includes other information such as the time required and the distance moved. It is important to focus on non-value adding operations (e.g.. storage and delays) and reduce these significantly. Flow process charts may relate to either materials or personnel but in factory layouts one generally considers the material type of flow process chart. The chart is used to describe where materials enter the process and the subsequent operations, transportations, inspections, delays and storages to which these materials are subjected are recorded in the order in which they occur. The material flow process chart can then be used to consider and refine the factory layout in order to optimise the layout. Personnel flow process charts can also be generated by conventional work study type methods. The relatively small savings to be made mean this is not generally worthwhile. A simple check list for the creation of a flow process chart and further details on flow process charts is given below:

1. Flow Process Chart Check List

Operations:

1. Can the operation be eliminated by:

    (a) The use of different materials?

    (b) A change in the design of the part?

2. Can the operation be combined with some other activity in a way which will reduce the unit production cost?

3. Will a change in the sequence of the operations be of value?

4. Can the operation be performed more economically through the use of different:

    (a) Equipment?

    (b) Tools, jigs and fixtures?

5. Can the layout of the work station at which the operation is performed be improved upon?

6. Would it be economical to subcontract the work?

7. Will subdividing the operation help?

8. Is the operation performed by personnel who will minimise the labour cost per unit?

9. Should the operation be performed at some other location in the plant so as to minimise handling costs?

10. Are working conditions, such as heat, light, and ventilation, satisfactory?

11. Is the equipment being operated properly?

12. Are the most economical materials being used?

13. Can anything be done to reduce scrap and defective output?

14. Is the work scheduled in economic batch quantities (EBQ)?

15. What can be done to reduce the EBQ.

Quality Control:

1. Is the inspection necessary?

2. Are you inspecting before you add value to the part? Rejections after high value adding operations cost a lot of money.

3. Is the inspection before or after a bottleneck?

4. Are the appropriate gauges being used?

5. Can sampling inspection be substituted for 100 per cent inspection?

6. Can the finish, tolerance, and allowance requirements be relaxed?

7. Can the inspection be more economically performed by the machine operator than by an inspector?

8. Is anything to be gained by using statistical quality control techniques in the manufacturing departments?

9. Can the layout of the station at which the inspection is performed be improved upon?

10. Will it help to have parts delivered to a central location for inspection, or is it better to have inspections performed at various production centres?

11. Can a number of inspections be combined to reduce handling time?

Transportation:

1. Can the distances travelled be reduced by a change in the plant layout?

2. Can quantities transported at one time be increased to reduce unit handling costs?

3. Will it be economical to replace manual methods by mechanical methods?

4. Are materials loaded and unloaded at the correct locations?

5. Is the most efficient kind of mechanised equipment being used?

6. Is the equipment being operated at the correct speed?

7. Can handling be made easier by the use of containers, racks and trays of appropriate design?

8. Can some operations be performed while the material is being transported?

9. Can cheaper labour be used to handle and transport material?

Storages and Delays:

1. Can the delivery of materials be scheduled to eliminate or reduce storage time?

2. Are storages caused by order quantities which are too large?

3. Are materials stored at the most convenient locations?

4. Are materials stored in such a way as to minimise breakage, deterioration, and theft?

5. Is the layout of the storeroom such that materials being delivered or received can be loaded and unloaded with little difficulty.

6. Can the number or length of storages and delays be minimised by:

    (a) Establishing better production schedules?

    (b) Providing wider aisles or more aisles?

    (c) Increasing the output capacity of the plant?

    (d) Combining certain activities?

    (e) Performing more than one activity at a given location?

7. Is time lost because of frequent job transfers?

8. Do the employees experience delays because instructions are not made available on time or because production facilities, such as men, machines, and materials, are not available when needed?

Check lists of this type are of a fairly general nature and will not necessarily lead to specific ideas for improvements. But for a list such as this to have a wide application, it is necessary that it be somewhat general. More specific questions should be developed for different activities.

Part 6: Quality control flowchart and schedule

The QC activities are best considered by reference to a quality system overview/flowchart and a quality system schedule. These can be used to ensure that the quality function is not neglected in the factory layout.

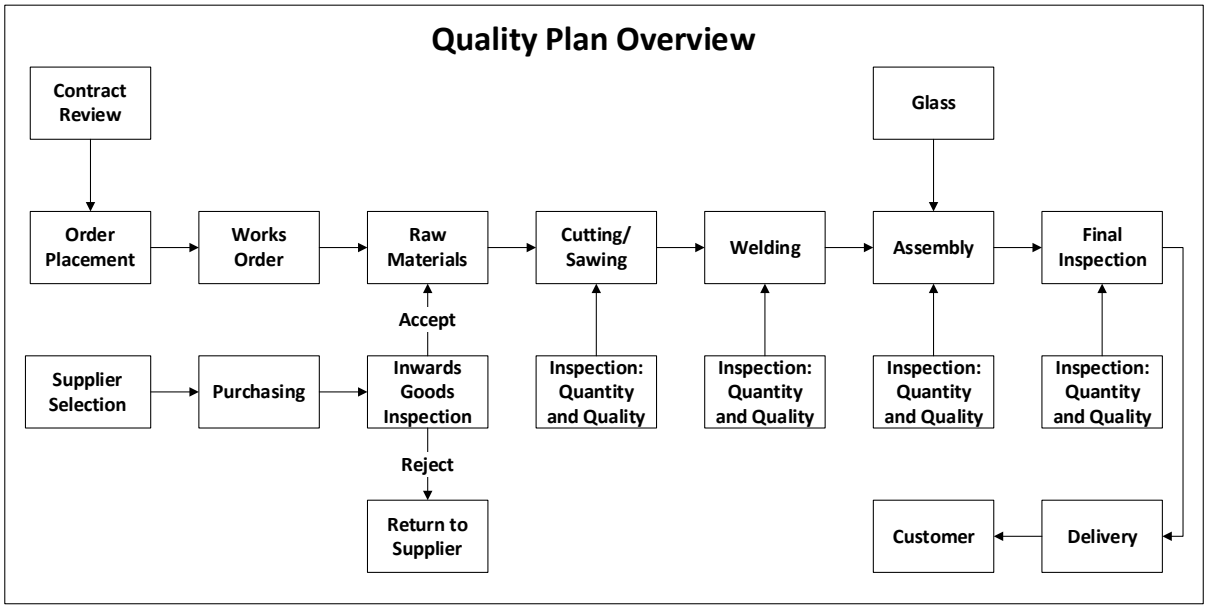

Figure 5: Quality plan overview

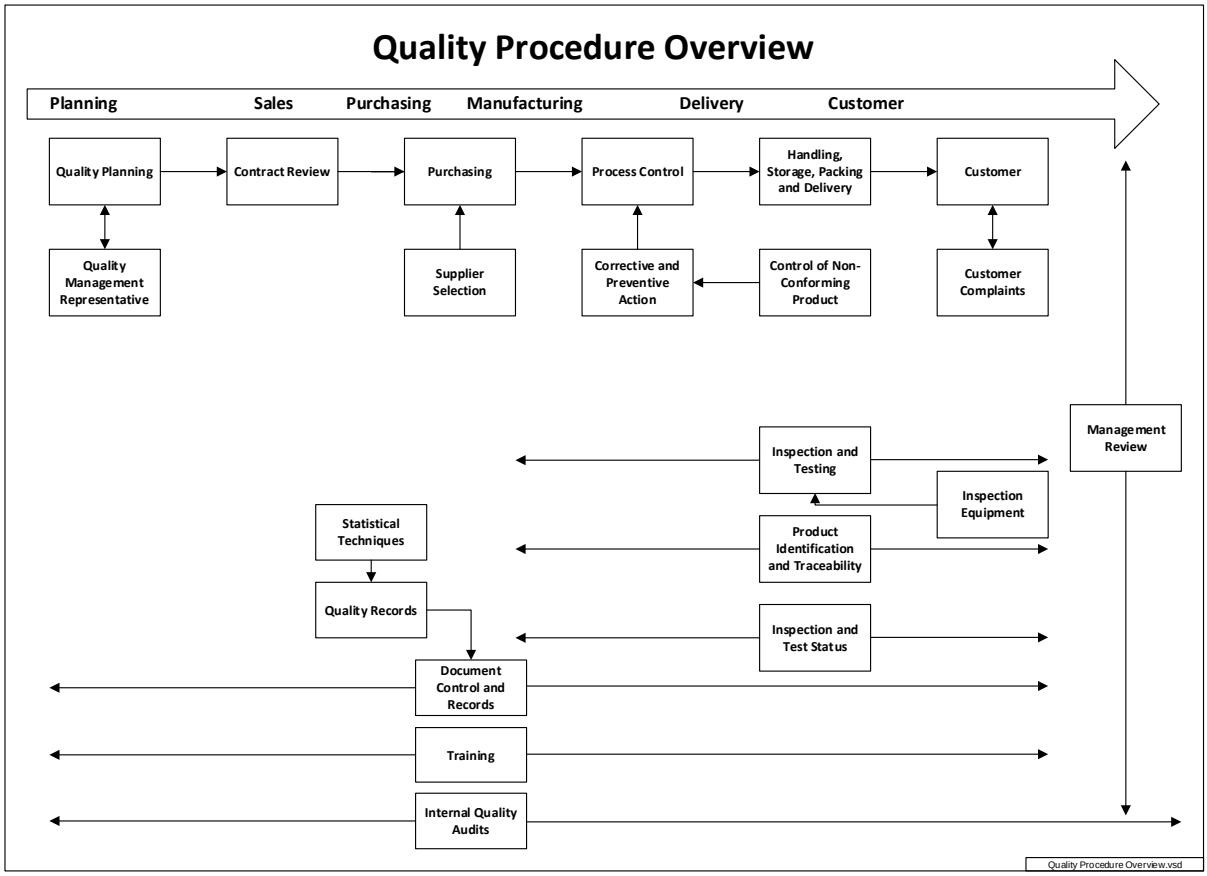

Figure 6: Quality procedure overview

Part 7: Miscellaneous equipment

In addition to the standard processing equipment there is a need for work benches and transport racks (toast racks).

Drawings of these are provided in this section to allow any competent carpenter or steel fabricator to manufacture racks and benches for window fabrication. The designs presented can be modified to suit the fabricator needs.

A particular point is that processing benches can be equipped with a shelf under the bench to store tools and fittings.

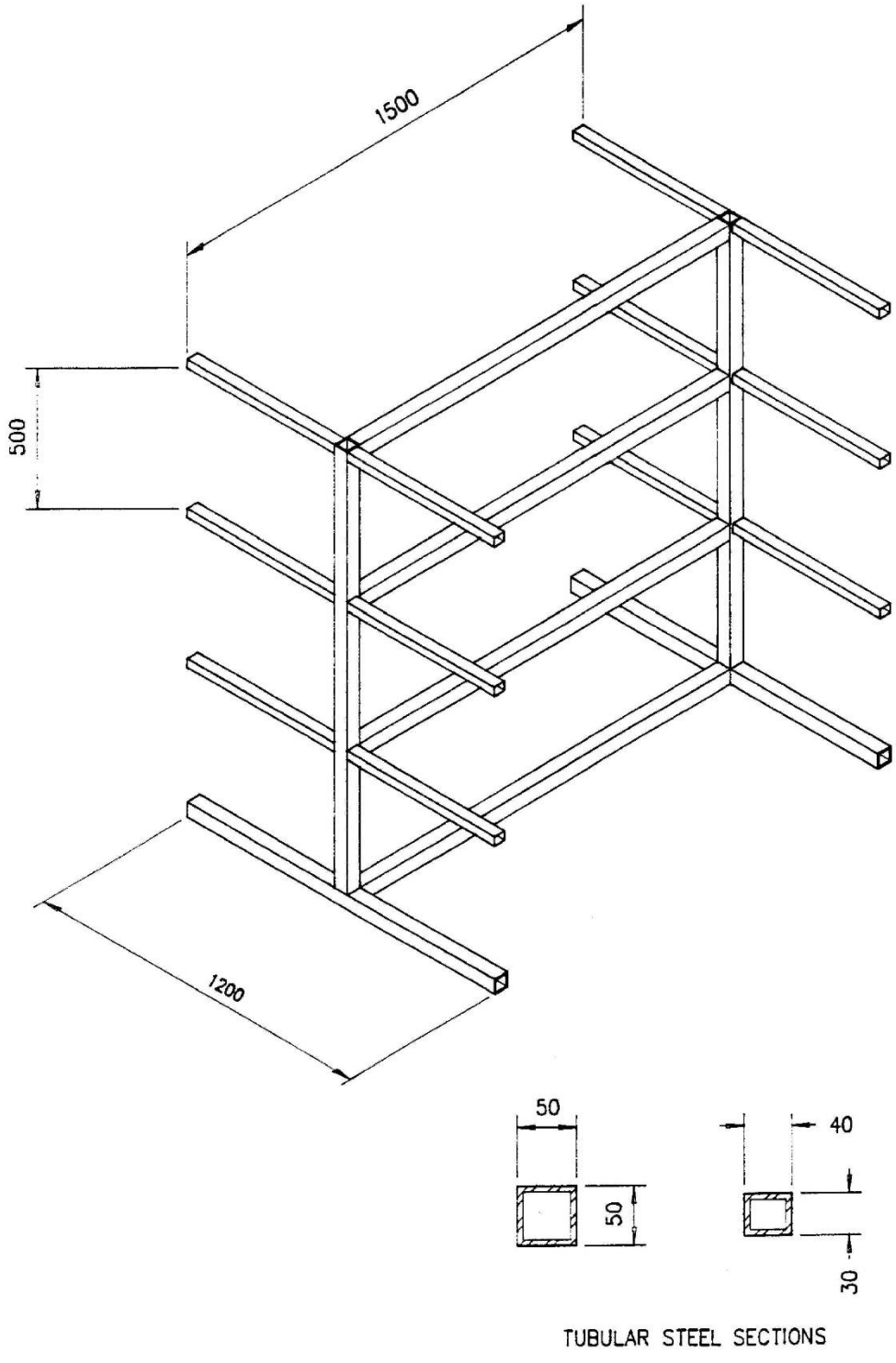

Figure 7: Profile and Reinforcing Rack

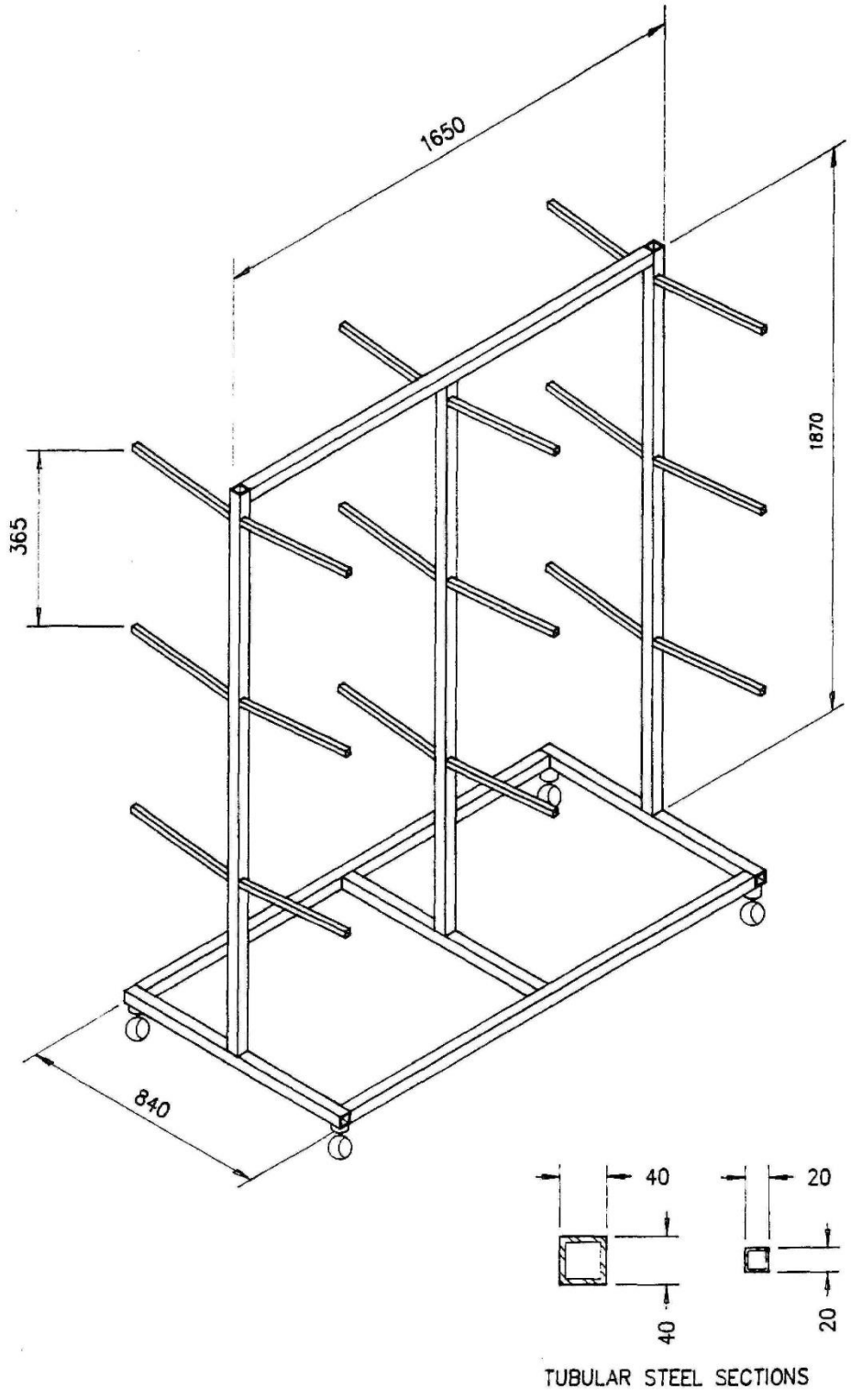

Figure 8: Cut Profile Trolley

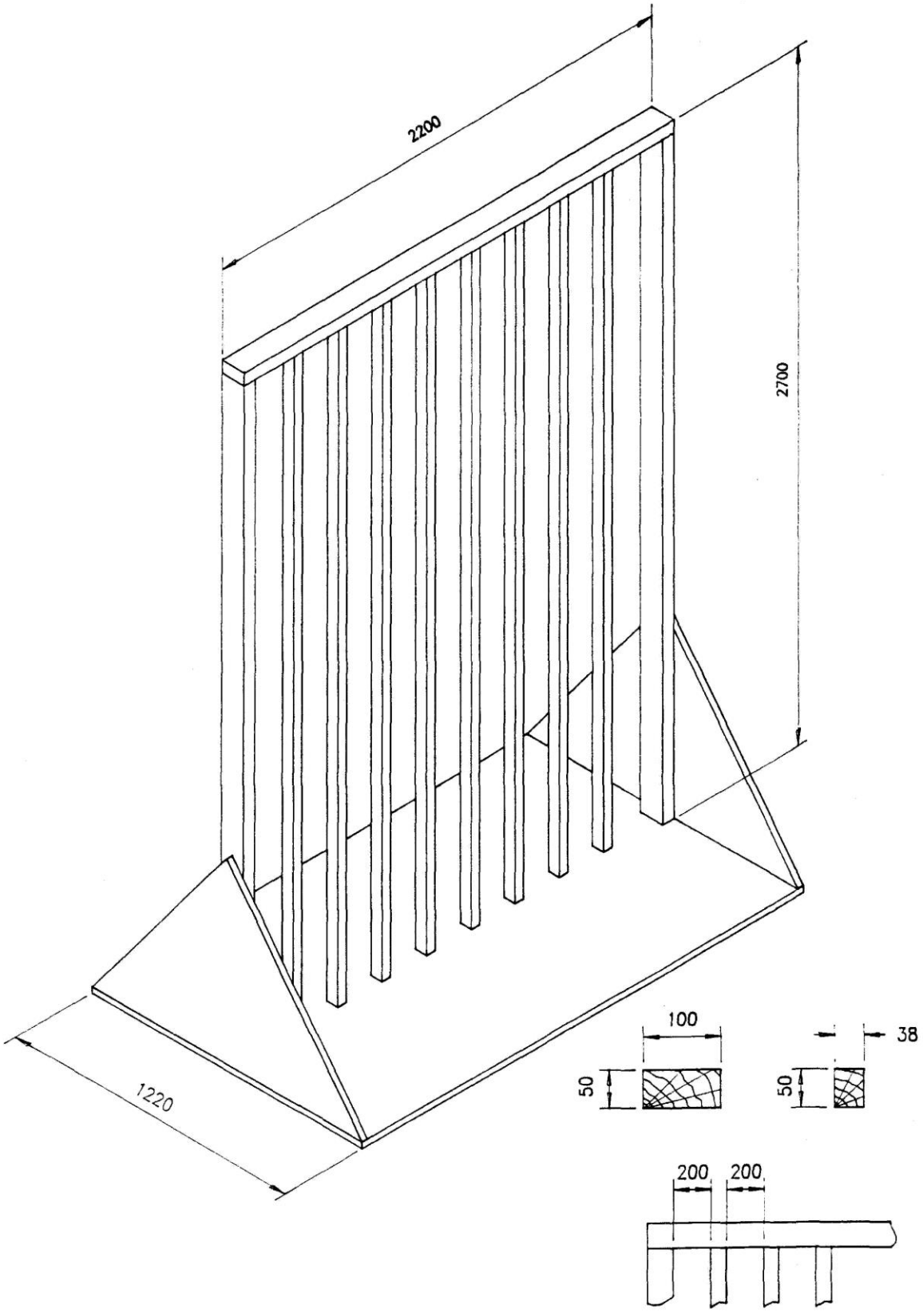

Figure 9: Outer Frame Toast Rack

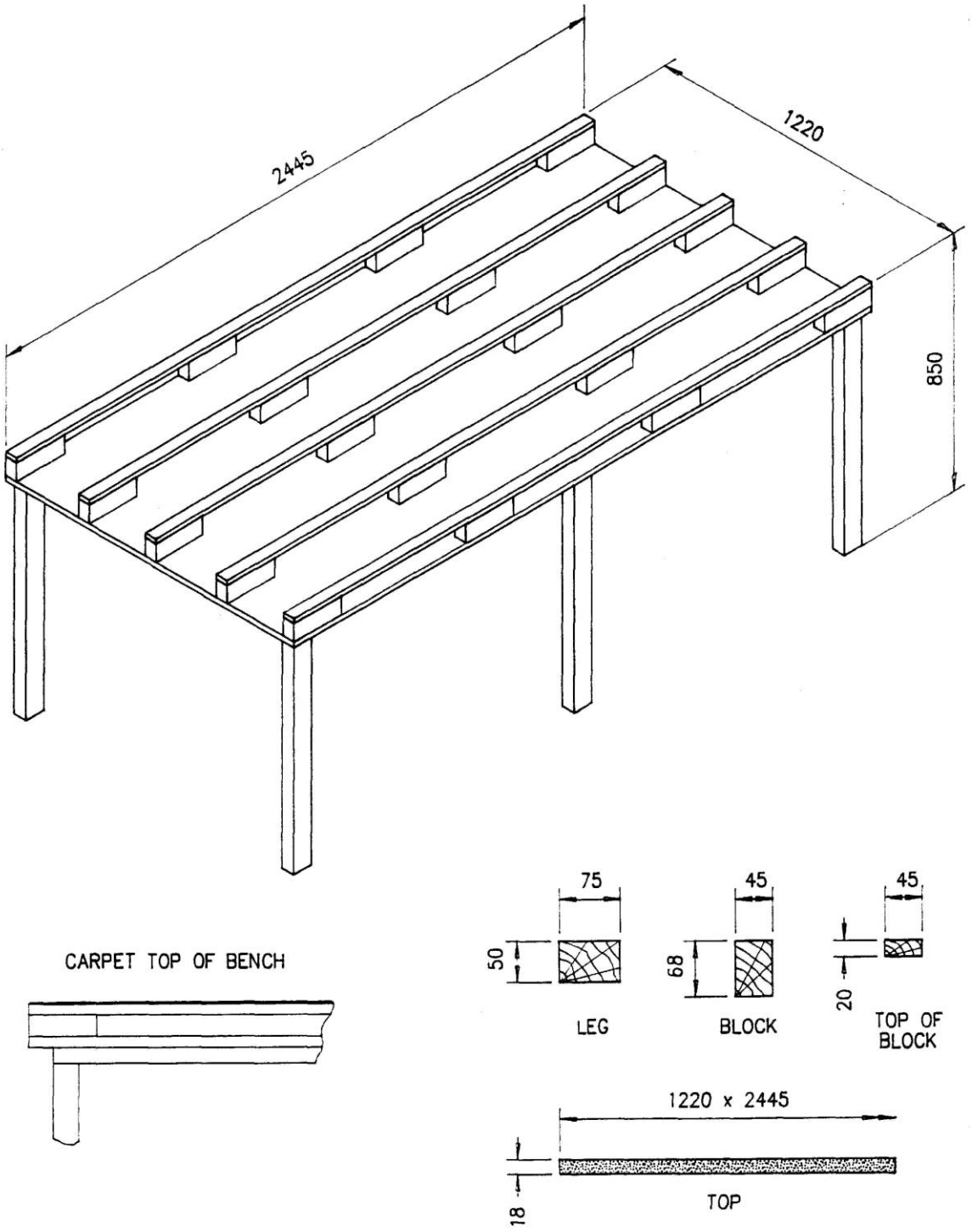

Figure 10: Standard Workshop Bench

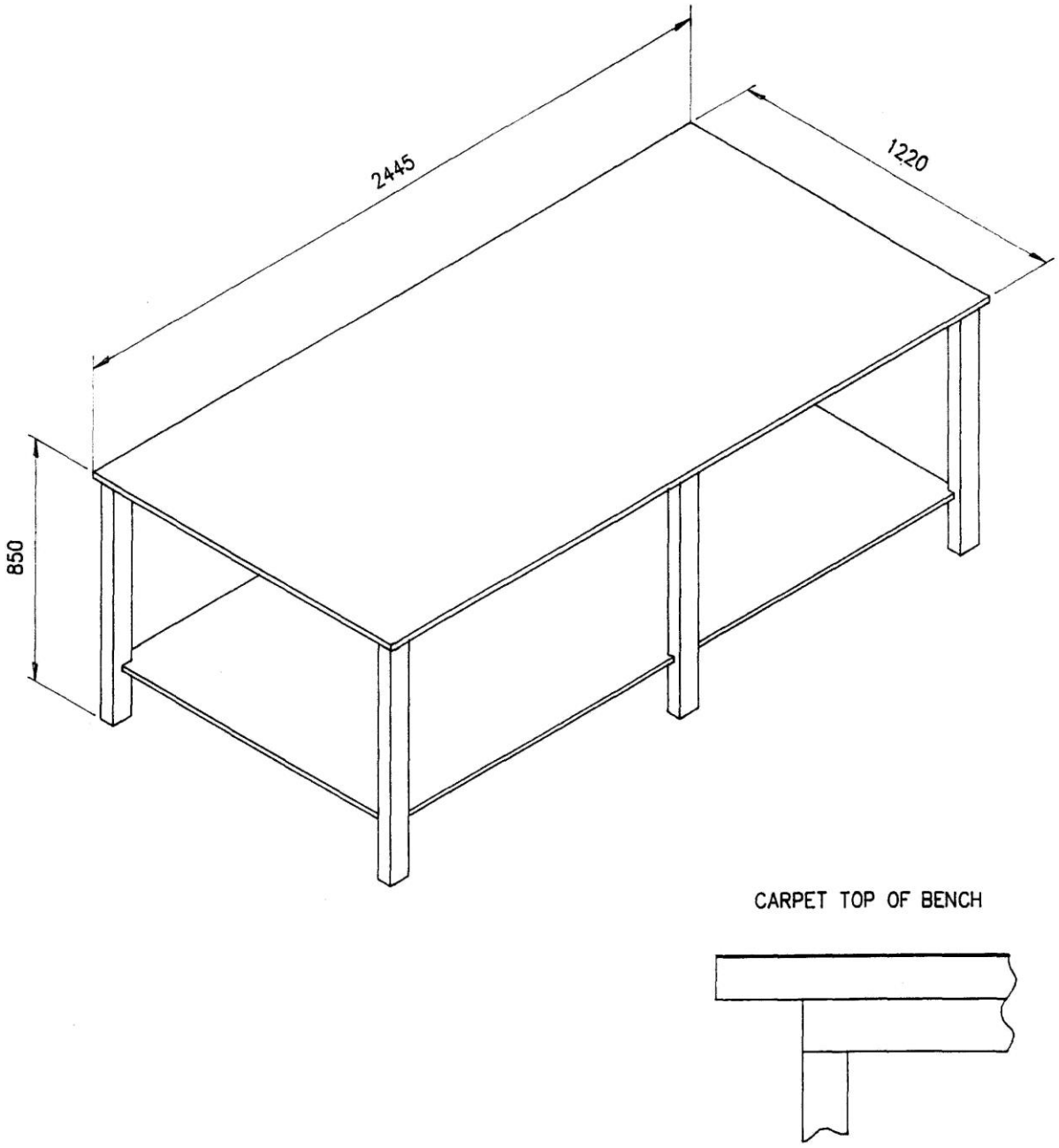

Figure 11: Processing Bench

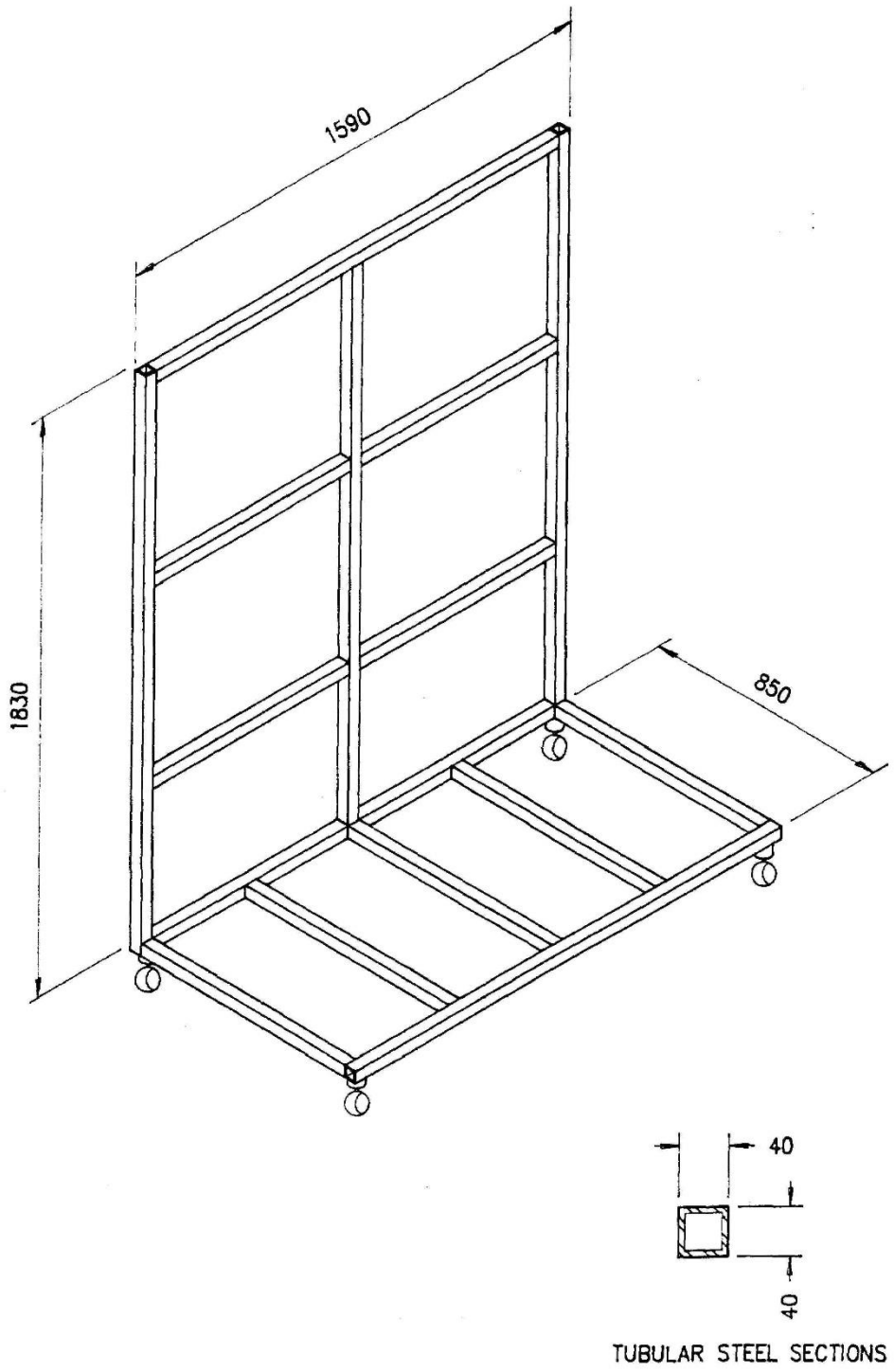

Figure 12: Finished Window Trolley