Factors affecting efficiency in the production of architectural drawings

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BUILDING PRACTICE NOTE

FACTORS AFFECTING EFFICIENCY IN THE PRODUCTION OF ARCHITECTURAL DRAWINGS

by

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INTRODUCTION

This paper contains recommendations for improving both the quantity and quality of graphic information produced by the building design team. However, before discussing the specific aspects, one must reconsider the basic uses of the production information created in the design/build process in order to develop criteria for assessing the suitability and quality of the information. This, unfortunately, is a task for which few busy practitioners can afford the time.

Figure 1 illustrates the basic process of information transfer in the design and construction of a building, from client brief to final building. When the process is viewed in this way, it immediately becomes apparent that almost every participant in it - client, architect, consulting engineers, contract managers, estimators, etc., - is a processor of information. Each takes in information in one form, processes it according to his special needs, and sends it out in another form to be passed on to the next participant in the process. The structural engineer, for example, receives information in the form of the soil conditions and topology of the site, the building layout required, and the relevant codes and standards. He then prepares his design in the form of drawings and schedules of a structural solution, which will then be incorporated and integrated by the architect into the rest of the emerging detail design. The line of information transfer ends with the site personnel who usually simply carry out orders.

The nature of the production information depends mainly on its purpose, but, it will also vary according to the training, ability and inclination of both the transmitter and the receiver of the information. From the architect's point of view, one can identify three distinct purposes for which production information should be prepared. The first is to present the design concept to the client or employer, who may not have an extensive understanding of design drawings. The second purpose is to make estimates and the third, to build the final product. Each purpose comprises a particular type of information. The information required by the estimators, for example, is different from that eventually needed by the site personnel who will actually erect the building. It should also be noted that estimating and building are generally not carried out by the people responsible for presenting the contract; a case in point is the set-up of most medium and large firms, in which the estimates are done by an independent group of specialists located at the head office.

The architect relies on three traditional media of information exchange. These do not include the electronic medium, which basically serves to translate electronic information into any of the traditional media. These media are: written (e.g., specifications, brochures and descriptions), graphic (e.g., drawings and working drawings) and numeric (e.g., quantity statements, bills of quantities and cost estimates).

TABLE 1

Medium	Purpose for which information is required		
	Presenting	Estimating	Building
Written	Very important, especially in construction, presentations of perspective, colour, modelling, etc.	Very important. Specification must be exact since possibility of confusion over price and performance exists.	Very important; should be clear, simple and accurate.
Graphic	Generally very brief and from building user's viewpoint.	Although important, accuracy not essential; large scales used since margin for error is large.	Needed to identify specified components; hence important for purchasers but less so for site personnel. Necessary only to avoid confusion.
Numeric	Used in floor-type breakdowns of superficial areas and in approximate budget figures.	Important but can be, and in North America, usually is, produced by contractor's estimator, not design team.	Not very important to site personnel since needed information is usually expressed on drawings, but necessary in project scheduling.

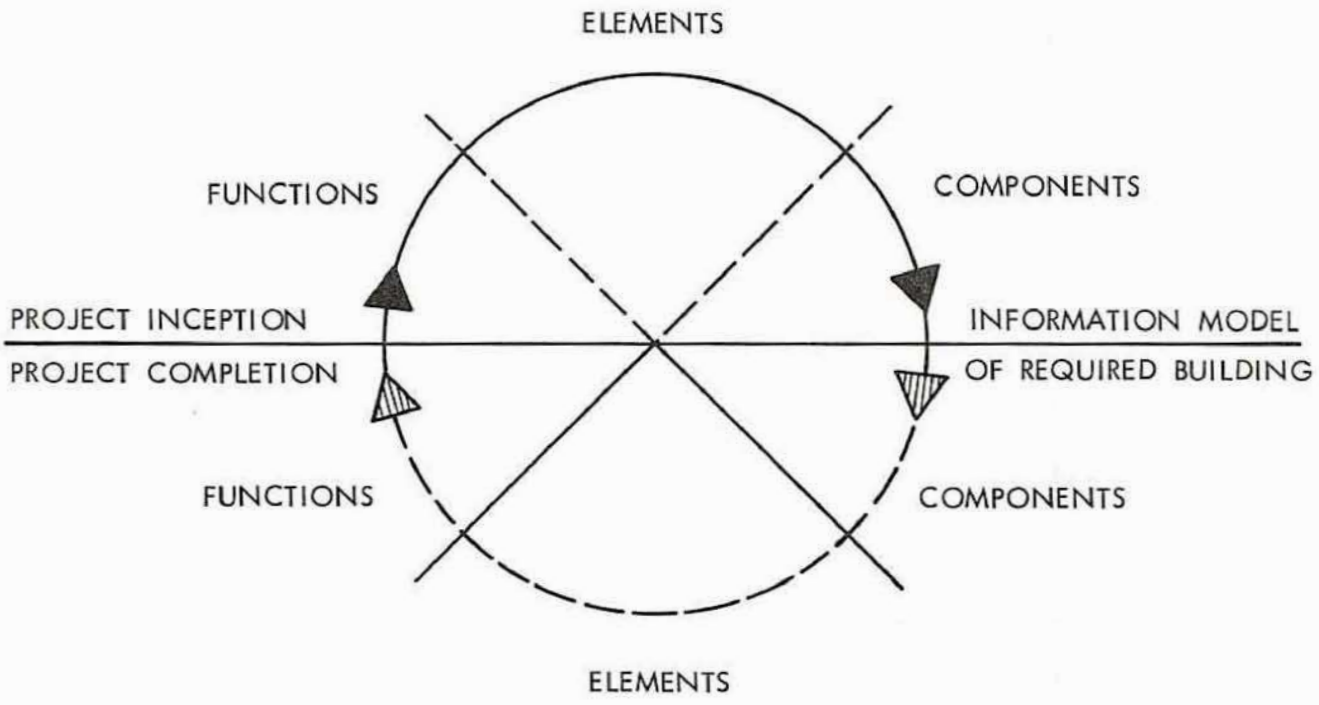


FIGURE 1

THE TRANSFER OF INFORMATION IN THE DESIGN AND CONSTRUCTION PROCESS

BR 6228-1

GRAPHIC INFORMATION

The following sections discuss in detail the production of graphic construction documents, that is, working drawings, with a view to shortening the time span involved, reducing the possibility of errors and omissions, and increasing quality and profitability. To achieve this, one must standardize the production process as much as possible.

The question then becomes: "What can be standardized in graphic documentation other than the already standardized drafting sheets and title blocks?" The answer is to examine past projects for repetitive work in areas such as general details, wall section component details, unit plans for often-repeated work (washrooms, etc.), general notes and schedules. Besides saving production time, establishing a standard detail collection would:

(a) provide a reference file of working drawing components proven in previous projects to be reliable and accurate,
(b) save time and money at the working-drawing production stage, and
(c) prepare the architectural firm for an eventual changeover to computer-aided design (CAD).

The last but most important question to be considered here is economic feasibility. Some of the changes in drawing production suggested later require a large capital outlay, although others can be achieved by simply streamlining office procedures. Only the people in charge of the firm can decide on the best approach for their situation.

EFFICIENCY IN THE DRAFTING ROOM

The many mechanical drafting aids currently used in offices are too numerous to mention. While these aids, which include stick-on lettering and lettering machines, can improve the graphic quality of the drawing, they cannot replace the draftsman, who remains an essential part of the design process. Also, the cost of using these aids must be taken into account and weighed against financial factors and the workload of the practice. This paper will restrict itself to considering direct ways of reducing the actual time spent at the drafting board in repetitive work.

Precut sheets with preprinted borderlines and title blocks are one way of eliminating the drudgery of repetitive drafting. A second step would be to prepare preprinted sheets (see Appendix 1) of finish, door and window schedules since the frames of the schedule tables, the titles and most of the notes are repeated. Adopting this suggestion depends, of course, on the printing costs and the volume of repeated jobs in the same category. An alternative would be to prepare several master copies of different layouts and to print sepia copies when required.

General notes may be typed on sticky-back copies prepared by the printer; specific notes on a project can be added at the end. Adopting this technique would save the considerable time spent on hand lettering. There are also several methods of composite drafting which, with a

minimum expenditure of time and money, will increase the efficiency of the drafting room if properly applied.

STANDARD DETAILS

As mentioned previously, compiling a standard detail collection is one way to reduce drafting time and costs and eliminate errors in re-drafting details in future projects. To make this collection workable, these procedures should be followed:

a) Details should be drawn on plastic drafting film.

b) To establish the detail sheet size, the typical drafting sheet, excluding the title block and margins outside the drawing border lines, can be divided into blocks of identical size, approximately 210 x 275 mm on ISO-size paper (approximately $8\frac{1}{2}$ x 11 in. on the P-series size of paper).

c) Although more than one detail can be placed on a sheet, all the details on a given sheet should be related to one another.

d) The principal components of a detail should be drawn on a master copy which is stored in a collection file. This copy should contain the scale, title, and coding designation of the detail.

e) A plastic film, or sepia copy, should be prepared from the master copy and filled in with all the details of a particular project including the dimensions and material symbols. The collection file should contain a copy of the final product.

f) Once the individual details have been copied (see e)), they should then be arranged on a regular-size sheet (Appendix 3) and printed on a second plastic film or sepia copy to be stored with the originals for the project.

g) The title and coding designations must be shown on both the master copy and the finished detail for filing purposes and later retrieval. The details should be numbered consecutively and coded according to category. Each detail category should have its own index, on either an index sheet or a card file. A number of suggested categories are listed in Appendix 2.

PHOTODRAFTING

For remodelling or renovation projects, drafting time in the office can be reduced by using elevation photographs of the building in its existing state. The scale of the photographs can then be established. Even elaborate elevation drawings can be produced quickly with this technique. Notes and leaders can be added to the photograph to identify design requirements (Figure 2, left).

Photomontage, which is usually a combination of photographs and perspective drawings, can be a very effective and efficient way of producing perspectives and, depending on the angle from which the original photograph was taken, elevation drawings for infill projects. This rendering is then enlarged photographically to the required size on white paper or film that is easy to colour and mount. Watercolours, markers or pencils can be used to add colour to the photocopy (Figure 2, right).

Old, nonreproducible drawings do not need to be redrawn; instead, they can be photographed full scale and printed on a clear plastic drafting sheet which can serve as a base. All subsequent additions or deletions can then be shown on overlays. A similar method can be used to restore worn, discoloured drawings and create revised drawings. To restore a drawing, a reduced-size negative is prepared. Smudges and stains are then removed from the negative and faded lines are carefully redrawn. At this stage one can also make all the required revisions to the original. The parts of the drawing to be changed can be deleted and the new elements drawn in. Since the negative is much more compact than the original drawing, the amount of work is minimal. The negative can then be re-enlarged, printed full scale and used as an original drawing. (See Appendix 3).

OVERLAY DRAFTING

Overlay drafting (or pin graphics, as it is sometimes called, because of the pin bar used to achieve absolute precision in holding overlays one on top of one another) can save considerable time.

Suggested Techniques for Overlay Drafting (See also Appendix 3)

a) All sheets should be precut with preprinted border lines, centering marks and title blocks.

b) The base sheet (1) is prepared by the architect, and contains the building gridlines, column outlines, perimeter walls, interior bearing walls and partitions, and stairs and elevators. Plastic drafting sheet copies of (1) are printed and issued to all the consultants. When changes occur, these copies are returned by the consultants and destroyed. The original of (1) is then revised by the architect and new copies made for distribution.

c) The architectural overlay (2) is prepared by the architect and contains the nonbearing partitions and the door swings. A composite print of (1) and (2) is sometimes issued instead of base sheet (1) to the electrical and mechanical consultants.

d) The architectural overlay (3) is prepared by the architect and contains dimensions; notes; room, door and window coding; titles; etc. A composite print of (1), (2), and (3) is the final architectural drawing.

e) The inverted ceiling overlay (4) is prepared by the architect using (1) as the base and issued as plastic drafting sheet copies to the electrical and mechanical consultants. In the case of changes, the same rules apply as for (1).

f) The flooring pattern overlay (5) is prepared by the architect or interior designer using (1) as the base.

g) The structural overlay (6) is prepared by the structural consultant using (1) as the base.

h) The plumbing (7), HVAC (8) and electrical overlays (9) are prepared by the mechanical and electrical consultants using (1) or a sheet combining (1) and (2) as the base which contains details pertaining to the consultant's specialty.

i) To establish the order in which each overlay is to be printed, a small legend should be placed on (1) preferably close to the title block. The legend should contain a predetermined space for each overlay code designation. This would simplify the instructions to the printer and clearly define drawing composition in the final print.

Overlay drafting, systematically applied, not only saves drafting time if the required facilities are available, but also makes it possible to produce multicoloured offset prints of the finished product. For example, reproducing the building lines in black on white, the HVAC overlay in blue and the electrical services in green will prevent the basic structural lines from being confused with those of the services. The enormous advantage of easier reading, fewer mistakes and easier interpretation of drawings prepared in this way is obvious.

THE COMPUTER AS AN AID IN DESIGN

The electronic digital computer is essentially a device for handling information. Since the design and construction process requires such a complex information communication system, it is not surprising that for the past twenty years a great deal of attention has been devoted to generating working drawings by computer.

Computers handle information in a binary digital code form which can be combined to represent almost any traditional information medium, whether written, numeric, or graphic, and can even produce music and colour. Computer systems design is based on this ability to manipulate a wide variety of information using a single code form.

Once fed into the computer, information can undergo three basic operations: processing, storage and retrieval. The importance of each of these operations in any computer application determines in many cases the hardware and software required in the application. The collection of basic information in a computer system is usually called the data base and is structured according to the priorities assigned to each computer operation. The data base structure determines, in most cases, the

success or failure of the data processing and retrieval, especially in computer applications such as computer-aided, building-production information.

Word processors were probably the first products of the electronic age to affect daily life in the architect's office. Their primary advantage was the ability to store, selectively retrieve and edit text. Most offices that bought or leased this equipment originally intended to improve the production of building specifications since the word processor enabled the architect not only to rework existing specifications of a particular building or building type, but also to introduce variations or new standards for new buildings without destroying the original specifications. Later on, other uses of the word processor developed, but were mainly in the administrative field; e.g., correspondence, report writing, mailing lists.

The substantial amount of text found in most working drawing sets suggests yet another use for the word processor. Notes, schedules, lists of drawings and other items stored physically on the drawings can now be kept and updated on the word processor as the project design is modified. Once the design has been completed, the text can then be printed on stick-on sheets, translucent film, etc., with the word processor, and placed on the drawings, thereby saving the draftsman's time and reducing the possibility of errors and omissions.

Design professionals have found computers helpful in solving problems such as structural frame analysis or energy consumption analysis which require complicated mathematical formulas and large quantities of input data. The rapid and accurate execution of such tasks have firmly entrenched computers as a design tool in this field.

Computer-aided architectural design (CAD) and drawing production, with its promise of improved drawing quality and increased productivity, is unquestionably the most attractive application of computers for the building team. So far, it has also been the most expensive and least-tried application.

In the early, optimistic days it was expected that all designers would eventually use visual display units to develop and immediately evaluate their design ideas on the basis of quantitative criteria such as cost, day lighting or heat loss. They would then simply press a button and all the design drawings, specifications and quantity schedules would be printed instantaneously. Unfortunately, the high degree of sophistication needed in the data base has prevented this Utopia from materializing. For instance, the human designer has an astute three-dimensional understanding; he can readily see that a certain wall detail is attached in a given way to a floor detail, and that it cannot be seen, say, from the front of the building. These concepts are very difficult to express in computer programs; hence, most CAD systems are still two dimensional.

Few CAD systems approach the complexity of an integrated interactive data base, that is, one which enables direct input from drawings to calculations and vice versa, and those that do are very

expensive. However, there are many systems which have concentrated upon the production information process which are much less expensive. Furthermore, most of these systems concentrate on computer-aided graphics, one of the more obvious and hence more saleable commodities.

The figures showing the improved productivity of automated drafting compared with manual drafting are impressive. According to several published reports the ratio varies from 2:1 to 20:1, depending on the type of drawings produced. Naturally, in the case of complex repetitive drafting, the machine will clearly surpass the human.

A computer system for graphics production may cost $90,000, whereas an integrated data base system capable of interactive design may cost $250,000 (at 1981 prices). As in all computer systems, these prices include both hardware and software components. The essential requirements for hardware in a graphics system, which are also very expensive, are: over-all good quality, a high-resolution visual display unit, a large high-calibre plotter, and adequate storage capacity.

It is not easy to assess the cost effectiveness of a computer-based system for an architect's office. Firstly, the size, workload, and often the type of work (e.g., housing versus commercial) change with time; secondly, the various costs incurred are difficult to isolate and evaluate. In addition to the initial capital cost of the system, one must consider the maintenance costs for both hardware and, less obviously, software. Also, there are training costs as well as the cost of working with both manual and computer systems during the trial period. However, once the system functions properly and the work for which it has been designed is available, substantial savings in manpower and improved quality of the end product (i.e., drawings) are inevitable.

Finally, the most important determinant of any computer system is the people using it. Great care must be taken to determine and allow for the reactions of all concerned, from draftsmen to serious designers, since many people have fixed, irrational ideas about computers.

FIGURE 2

EXAMPLE OF PHOTODRAFTING

APPENDIX 1

R O O M F I N I S H S C H E D U L E

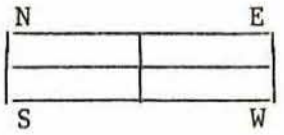
(Extra spaces should be left in each column for additions)

NO	NAME	FLOOR								BASE					DADO					WALL					CEILING					ACCES-SORIES					REMARKS
		CONCRETE	TERRAZZO	QUARRY TILE	VINYL TILE	BROADLOOM BY OWNER				TERRAZZO	QUARRY TILE	VINYL			VINYL FABRIC 1200 mm	CERAMIC TILE 2100 mm				UNFINISHED	PLASTER	WALNUT			PLASTER	GYPSUM BOARD	ACOUSTIC TILE			COUNTER CUPBOARDS	LOCKERS				
1				*							*				*						*				*										Inset door mat
2			*							*											*						*							See dwg 7 for terrazzo
3					*							*									*						*				*				
4		*				*						*										*					*								
5					*						*										*				*						*				
6					*							*									*						*								
7			*													*					*				*										

ROOM MATERIAL, FINISH, AND COLOUR SCHEDULE

PROGRAM NO.	ROOM NO.	ROOM NAME	FLOOR	BASE	WALLS	CEILING	CLG HGT	COLOUR	REMARKS

Notes: Use compass points for variations of materials, finishes, or colours in same space. Use standard abbreviations.



APPENDIX 2

D E T A I L C A T E G O R I E S

BROADSCOPE

D.1 Sitework
D.2 Exterior Envelope
D.3 Interior Enclosures
D.4 Floors
D.5 Ceilings
D.6 Door-Glazing
D.7 Fabrications
D.8 Conveying Systems
D.9 Special Construction

S U B - D I V I S I O N I N D E X

D.1 SITEWORK

01 Concrete Walks, Joints
02 Walk Paving
03 Concrete Curbs
04 Concrete Steps, Railings
05 Stair Paving
06 Planting Area Construction
07 Pole and Sign Bases
08 Guards, Gratings, Covers
09 Fencing
10 Drainage, Irrigation
11 Pools, Fountains

D.2 EXTERIOR ENVELOPE

01 Poured Concrete Walls
02 Precast Concrete Walls
03 12 in. Brick and Block Walls
04 12 in. Concrete Masonry Unit Walls
05 8 in. Concrete Masonry Unit Walls
06 Brick Veneer and Metal Stud Walls
07 Stucco and Metal Stud Walls
08 Insulated Metal Panel Walls
09 Glass Curtain Walls
10 Glass Storefront Walls
11 Steel Roof Deck
12 Composite Concrete Roof Deck
13 Poured Concrete Roof Deck
14 Precast Concrete Roof Deck
15 Roof Expansion Joints
16 Roof Curbs
17 Skylights
18 Equipment Bases
19 Roof Access Hatches
20 Roof Ladders
21 Roof Drainage
22 Roof Walk Surfaces

D.3 INTERIOR ENCLOSURES

01 Poured Concrete Walls
02 Brick Walls
03 Concrete Masonry Unit Walls
04 Structural Tile Walls
05 Plaster and Metal Stud Walls
06 Plaster and Masonry Walls
07 Gypsum Wallboard and Metal Stud Walls
08 Movable Partitions
09 Operable Partitions
10 Glass Partitions
11 Wall Expansion Control
12 Wall Finishes

D.4 FLOORS

01 Concrete Floors on Grade
02 Formed Concrete
03 Precast Concrete
04 Steel Joists and Concrete
05 Steel Composite Floor
06 Expansion Control
07 Floor Finishes
08 Floor Penetrations
09 Floor Electrical

D.5 CEILINGS

01 Acoustical Tile
02 Plaster
03 Gypsum Wallboard
04 Insulation
05 Expansion Control
06 Ceiling Electrical
07 Ceiling Access

D.6 DOORS-GLAZING

01 Hollow Metal Doors and Frames
02 Aluminum Doors
03 Glass Doors
04 Rolling Doors and Grilles
05 Wood Doors
06 Folding Doors
07 Windows
08 Storefront Glazing
09 Glass Railings
10 Fixed Glass

D.7 FABRICATIONS

01 Steel Stairs
02 Ladders
06 Toilet Partitions
07 Cabinetry
08 Graphics-Directories
09 Lockers-Shelving
10 Booths-Kiosks
11 Furniture

D.8 CONVEYING SYSTEMS

01 Elevators-Passenger
02 Elevators-Freight
03 Escalators
04 Hoists
05 Conveyors
06 Pneumatic Tubes

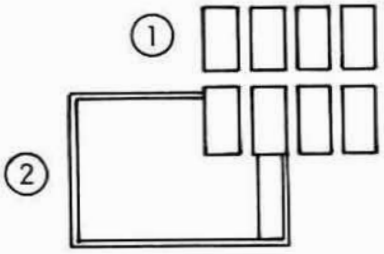
D.9 SPECIAL CONSTRUCTION

01 Bank Equipment
02 Athletic Equipment
03 Food Services
04 Educational Services
05 Automotive Services

APPENDIX 3

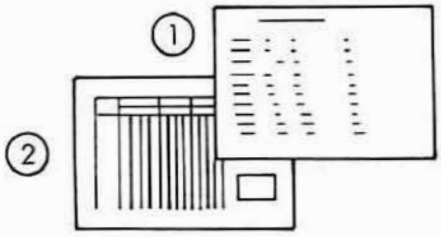
COMPOSITE DRAFTING - ORGANISATION CHART

STANDARD DETAILS



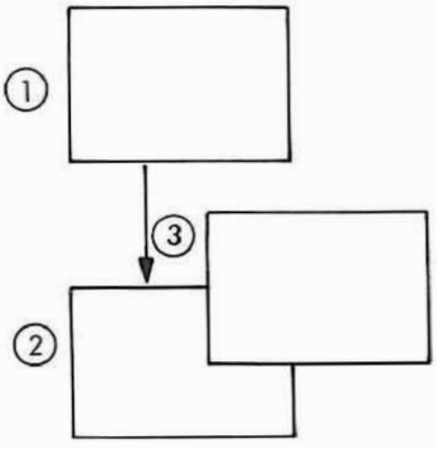
1. STANDARD DETAILS FROM COLLECTION FILE
2. BASE SHEET

SCHEDULES



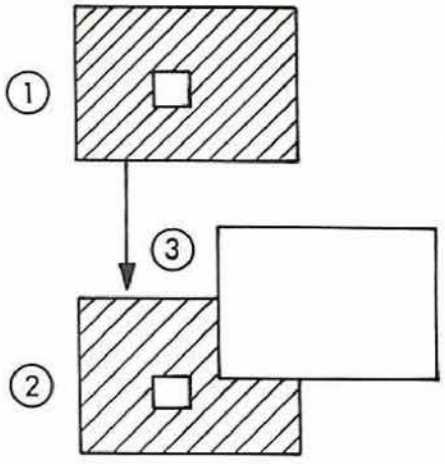
1. NEW TEXT OVERLAY
2. COMBINED BASE SHEET, TABLES AND STANDARD COMPONENTS

PHOTODRAFTING - SCHEME 1



1. ORIGINAL, NONREPRODUCIBLE DRAWING
2. OVERLAY - CONTAINING NEW WORK AND/OR NOTES
3. FULL SCALE PHOTOGRAPH OF ORIGINAL PRINTED ON TRANSLUCENT PLASTIC SHEET

PHOTODRAFTING - SCHEME 2 - PHOTOMONTAGE



(1) BASE SHEET - PHOTOGRAPH OF EXISTING BUILDING PRINTED ON TRANSLUCENT PLASTIC SHEET

↓

(2) FILL IN NEW CONSTRUCTION, NOTES ETC.

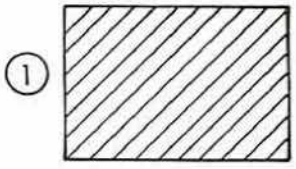
OR

↓

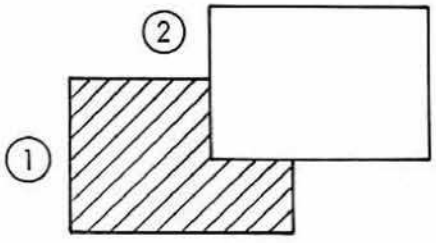
(3) USE OVERLAY FOR NEW INFORMATION BASE SHEET

OVERLAY DRAFTING

SITE PLAN

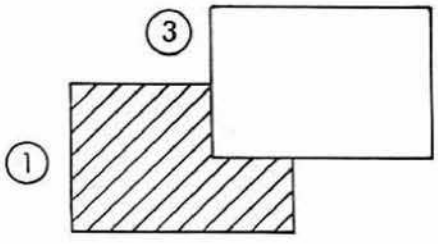


(1) BASE SHEET



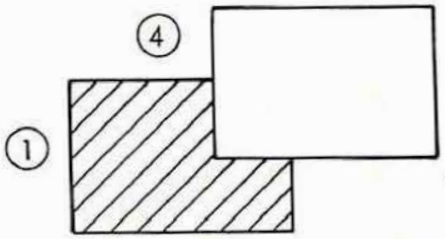
(2) DEMOLITION OVERLAY

(1) BASE SHEET



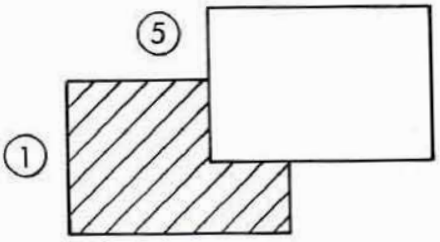
(3) EXCAVATION PLAN OVERLAY

(1) BASE SHEET



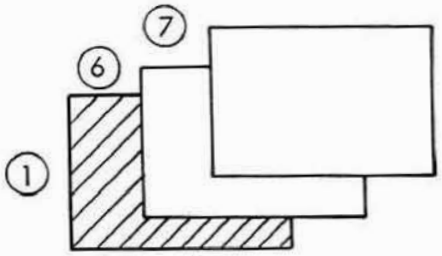
④ GRADING, DRAINAGE PLAN OVERLAY

① BASE SHEET



⑤ LANDSCAPE PLAN OVERLAY

① BASE SHEET

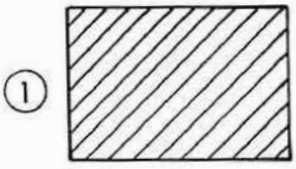


⑦ SERVICES OVERLAY

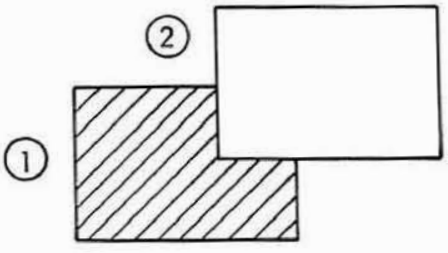
⑥ SITE DEVELOPMENT

① BASE SHEET

FLOOR PLAN

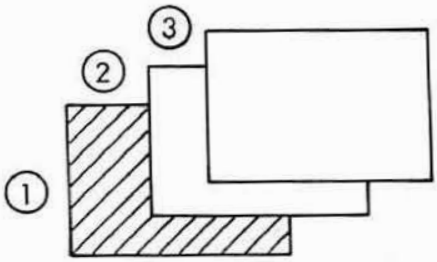


① BASE SHEET



② ARCHITECTURAL-OVERLAY

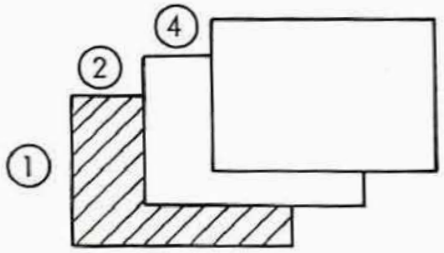
① BASE SHEET



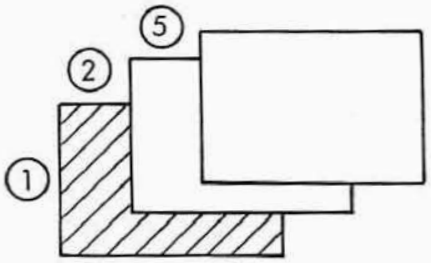
③ ARCHITECTURAL-OVERLAY

② ARCHITECTURAL-OVERLAY

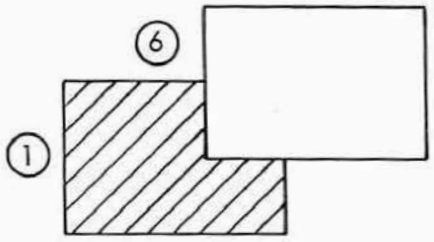
① BASE SHEET



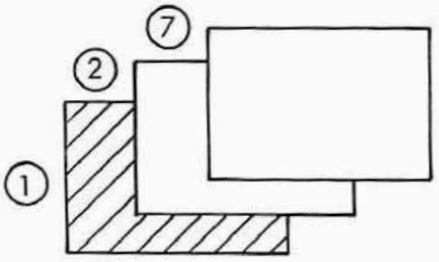
④ INVERTED CEILING PLAN
② ARCHITECTURAL-OVERLAY
① BASE SHEET



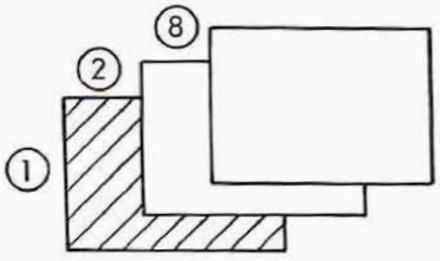
⑤ FLOORING PATTERN
② ARCHITECTURAL-OVERLAY
① BASE SHEET



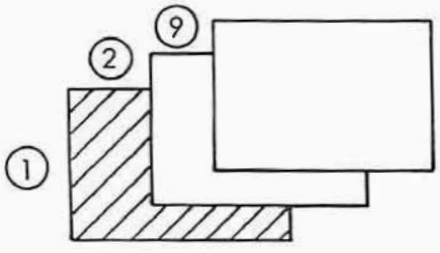
⑥ STRUCTURAL-OVERLAY
① BASE SHEET



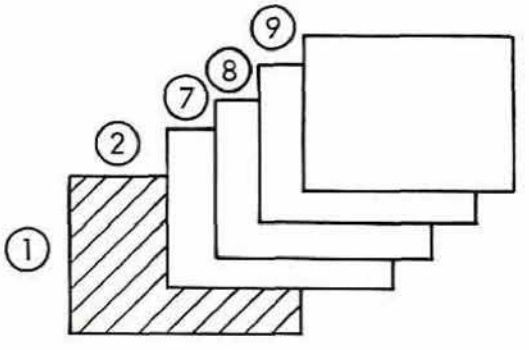
⑦ PLUMBING-OVERLAY
② ARCHITECTURAL-OVERLAY
① BASE SHEET



⑧ HVAC-OVERLAY
② ARCHITECTURAL-OVERLAY
① BASE SHEET



⑨ ELECTRICAL-OVERLAY
② ARCHITECTURAL-OVERLAY
① BASE SHEET



(9) ELECTRICAL-OVERLAY

(8) HVAC-OVERLAY

(7) PLUMBING-OVERLAY

(2) ARCHITECTURAL-OVERLAY

(1) BASE SHEET

NOTE:

EXAMPLES OF OFFSET PRINT POSSIBILITIES SHOULD BE COLOUR-CODED; E.G., PRINT THE BASE SHEET (1) AND ARCHITECTURAL OVERLAY (2) IN BLACK, AND THE OTHER DISCIPLINES IN INDIVIDUAL COLOURS

BR 6228-6