SHADE ROOF SYSTEMS

for

OPEN DECK CAR PARKS, PLAYGROUNDS AND SIMILAR AREAS

B T DAVIS
McWilliam Consulting Engineers

"..... we don't shop here much now, we go over to Carindale - you can park the car under cover - there's no shade here ....."

Comment by lady in supermarket
Mt Gravatt, Brisbane 1988

"..... even though those spots are less than 15m to the entry, they don't get used much - people prefer to park in the shade even if it means they have to walk up to 80m ....."

Comment by Shopping Centre Manager
Sunshine Coast 1988

"..... a schoolboy has sued the -- Government claiming he was severely sunburnt when his school teachers left him exposed in the sun for two hours at school swimming sports ....."

'Courier Mail'
Brisbane November 1989

"..... we will have to do something about roofing the car park and walkways here. Everyone comes in first thing in the morning or last thing at night. The shops are pretty well empty all the rest of the time ....."

Comment by Administration Officer
Roxby Downs Town Centre, South Australia 1991

SHADE ROOF SYSTEMS FOR OPEN DECK CAR PARKS, PLAYGROUNDS AND SIMILAR AREAS

B T DAVIS

SUMMARY

This paper addresses briefly the general requirements, forms, practicalities and relative costs of various systems for shading open car parks, playgrounds and similar areas in primarily warm to hot climatic regions.

INTRODUCTION

Many systems for providing shade have been built at some stage or other and in various scales and locations, however, the idea of covering large expanses for shade only has been carried through to actual construction in very few locations throughout the world.

Roofing car parks or at least the access paths for rain protection is quite common, but roofing primarily for shade only is effectively a new concept.

An intermediate approach whereby the access ways are rain protected, the parking bays shaded and the roadways left more or less open has much to commend it in terms of a cost, ventilation/user acceptance balance. A scheme along these lines was proposed for the Brisbane Airport in 1990. This is particularly so in areas like south-east Queensland where rain is relatively sporadic and sunlight intensity is quite high for much of the year.

This last point gives a lead to the need for such structures in the first place. There is no doubt that today's society perceives a problem, be it real or imaginary, in man/sun encounters. There is no doubt also that excessive sun exposure is bad for one's well being; however, one can see that an almost cocoon-like protectionist attitude is being incideously developed whereby any exposure to the sun is to be avoided.

The effect of this is that the sun seems to be getting harsher and man and his chattels (cars, etc.) not to mention his children are getting 'softer'. The so-called 'standard of living' of western cultures trends always to the tasks of going about one's daily routines (shopping, working, playing, recreation, etc.) being pleasurable necessities.

From a commercial viewpoint, one is reminded of the marketing edge gained by some stores in the 50's when they arrested passers-by with refreshingly cool conditioned air spilling out onto the footpath. It wasn't long before all other stores and public offices, etc. caught on.

Another aspect gaining attention is that vast acres of parked cars, not to mention multi-level parking structures themselves are little short of an eye sore from whatever position and distance they are viewed.

Many of our established school playgrounds and open public spaces could do with a bit of visual uplifting which could double as pleasant islands of summer shade.

It is somewhat surprising that small shade structures can be found in numerous cool temperate climate locations, yet, closer to home we tend to use, if at all, rather bulky and uninspiring shed-like edifices.

In summary therefore, the factors driving a swelling interest in covering what would otherwise be an extensive open paved area are:

- A desire by users for improved comfort levels which, once provided, soon become the required norm, for which read necessity;
- A widely held perception that sun exposure for however short a period is a health hazard;
- Commercial interest in going one better than the opposition; and
- Awareness of the visually, and sometimes physically offensive environment that such areas create.
- The gradual substitution of common sense by legal process in the horizons of our administrators.

BASIC REQUIREMENTS

Some factors influencing the desired outcome are:

- Extent of cover
- Rain or shade
- Height clearances and spans
- Reactions/anchors
- Visual demand
- Maintenance
- Economic reality
- Life of project
- Degree of landscaping
- Authority requirements

Some notes on these set out below.

(a) Extent of Cover

There is really no practical limit on the area that can be covered. Shade roofs up to as much as a square kilometre have been installed. There is little restriction on plan shape, nor for the matter vertical profile.

Given that we are covering car bays or other compact activity areas, it seems reasonable to take a modular approach. Roofing can then be provided in units at different heights, overlapping, etc.

Local weather patterns relating to prevailing winds, storm directions, sun angles, winter/summer variations, likelihood of hail storms etc. will give guidance on roof materials, slopes, overhangs etc. as usual.

There may be a case, following studies of patron visitations for covering only part of the whole area. It does not seem sensible to cover roadways, eg. also, it may be that only the perimeter car bays or those nearest the centre functions should be covered.

An important counter to wholesale shading which is not to be lost sight of is that it is pleasant to be in the sun on an otherwise cold day.

(b) Rain or Shade

A decision has to be made between providing shelter from rain only, or shade or both. As noted previously there is a strong case for rain-protecting selected walkways, disabled parking, pick-up/set down bays, etc. while shading general parking bays.

Control of rain run-off is a significant item in large area roofs. Ideally, it is best to 'gently guide' the water away from people places rather than to collect it in gutters, downpipes, etc.

In large open areas bathed in strong sunlight, glare is ever-present. While this can be reduced with suitably designed structures, it is better done with planting which can also provide a valuable shade element.

In general, rain protection structures cost significantly more than pure shade structures.

(c) Heights and Spans

The minimum height clearance for a roof over a car park bay of the type we are addressing here should be 3.5m. Against this, a height of 4.5m would allow the largest truck to drive through. As usual, the wider the spans the higher the structure should be.

In roadways generally the normal minimum height clearance is 4.7m to suit emergency and maintenance vehicles. a reasonably balance needs to be struck between practical minimum clearances and visually acceptable maximum (or minimum) heights.

In terms of clear spans, the normal planning dimensions apply as for any car park. Generally, the smaller the span the more obstacles in the way for parkers to drive into; the larger the span, the 'grander' the structure and higher the cost. (This comment on cost can, however, be turned around with some of the very light tensioned shade structures).

Heights above pedestrian and play areas should preferably exceed 3m to minimise the temptation of climbing.

(d) Anchorages

For structures on grade - not necessarily level - normal footings, tension or bracing anchorage, etc. are involved. Soils such as stiff sandy clay, or highly weathered rock are good. Loose sands, soft wet clays or hard rock can cause problems.

With a multi-level car park structure, the floor is usually a fairly heavy concrete slab, which gives reasonable opportunities for vertical support and tie-down. (It must be kept in mind that the overwhelming trend is to very lightweight roof structures and these in turn make the need for tie down and lateral restraint far more significant than vertical load carrying.

With a suspended floor he layout below is usually reflected in the parking layout above and so the column/wall bays should form the basis of the upper shade structure. In public areas and play grounds advantage should be taken of gardens and ponds for locating stay cables out of harm's way.

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(e) Visual Demand

As is noted later there is a wide range of structure systems available for roofing open areas. All are amenable to either significant or negligible architectural input as the project warrants.

Strong geometric or highly freeform elevations and plans can be provided to satisfy visual requirements from below, above or at a distance. Relating such forms to other major structures in the development is not different from any other design task. Small, vibrant structure forms with variable interspaces can add to the appeal of a park or play ground.

(f) Maintenance

It is a fact that as our construction techniques and materials become more sophisticated, not to mention increasing combinations of materials, so too does the need for properly programmed inspections and maintenance demand attention.

Whereas in earlier decades car parks were an unwanted necessity whose original design, maintenance and visual presentation clearly advertised the fact, they are now being seen as the 'front door' of developments and, as such, a key element in shaping the visitor's first and lasting impressions.

Importantly then, as with any other building project ,is the need to design the layout and physical elements in such a way that regular cleaning and, if need be, upgrading is facilitated.

(g) Economic Reality

Just as we have a wide range of construction systems available so too is there an equally wide cost range for roofing of large open areas. For example, a basic flat shade net roof may cost in the order of $30.00/square metre whereas a complex translucent barrel vault or similar system may be twenty times that cost.

Every project has its price determined by a cost/benefits/market position analysis. In the near future, however, as with so many aspects of the building industry user demand is expected to override what might hitherto have been a simple pragmatic decision as to the extent and quality of car parking or recreation facilities.

(h) Life of Project

In recent years the refurbishment cycle time has decreased quite dramatically, eg. as little as 5 years for some commercial projects. This should be kept in mind in developing any design and the expenditure to be made on it. (Thought should be given to the likely growth in the use of automated parking systems over the next decade. These will allow more cars to be stacked in a given area, and will influence decisions at the time of its installation on the need for and visual standards - at least internally - of future car parking structures).

(i) Degree of Landscaping

The future for soft landscaping is well assured. As well as perimeter and access delineation it can provide excellent glare control and a degree of shading, not to mention sheer pleasant surroundings.

An interplay of soft landscape and shade roofs with some active water features would seem to be a theme for key developments in the 90's.

In this content, freeform, lightweight roofing systems with their curved edges and undulating vertical profiles would have much to commend them over more conventional straight line and prismatic structures.

(j) Authority Requirements

All roofs of the nature considered here are permanent structures under the present building regulations, incl. BCA. There is normally no problem in having them approved structurally, although there may, in some instances where fabric, shade or translucent materials are proposed be a need to consider carefully fire requirements. For 2 or 3 storey structures relatively remote from other structures and alignments these materials are satisfactory.

Presently there is interest in adequate ventilation in car parks. While this is not likely to be a factor with surface parks, it suggests that any roof should have large openings to allow free air movement and day-lighting generally and at the same time to prevent any entrapment of channelling of heat and smoke in the event of a fire.

Another feature of concern to all involved with public car parks is that of personal safety and vehicle security. While this falls largely onto the Centre Management the Designer must consciously be aware not to design in 'back alleys' or clutter the area up so that visual or CCTV surveillance is impaired or rendered impossible.

On this same theme, supervision of play ground and public spaces should not be impaired by ill-placed shade structures.

It is interesting to note the following section from the Queensland Child Care Regulations 1991:

Outdoor Play Areas and Design

1. In a kindergarten, long day care centre or an occasional care centre, there must be;

   - outdoor play areas of at least the area determined using the formula -

     Outdoor play area (m^2) = licensed capacity x $7m^2$; and

   - a shaded area of at least that determined using the formula -

     Shaded area (m^2) = licensed capacity x $2m^2$

2. At least one half of the minimum shaded area mentioned in 1 above must be roofed.

3. In a limited hours care centre, there must be;

   - an outdoor play area of at least that determined using the formula -

     Outdoor play area (m^2) = licensed capcity x $5m^2$; and

   - a shaded area of at least $1m^2$ for each child of the licensed capacity.

CONSTRUCTION SYSTEMS

We may recognise two elements in this, viz. the 'roof sheeting' and the 'supporting structure'.

Under the heading of 'roof sheeting' we refer to the covering material which, in order of historic popularity and, coincidentally, increasing translucence, may be listed as follows:

(a) Non-Permeable

(i) Metal decks
(ii) rigid translucent sheets
(iii) structural fabrics

(b) Permeable

(iv) shade fabrics
(v) shade nets
(vi) lattices

Specific notes are made below in respect of each of these.

The type of supporting structure employed could range from conventional post and beam, portal frame and arches through to space frames and cable systems.

There is no rule to relate the one sheet material with any of the structure systems, eg. rigid translucent sheeting could be fixed to and supported by a cable net system; a spaceframe could be part of a post and beam structure, or, if suitably designed, it could be a lattice in its own right.

Having said this, however, it is noted that certain 'sheeting'/structure combinations have become more or less established and the use of the somewhat radical departures noted above may not come without some penalty in either development time or cost. A rough guide to decision making in this regard would be that, 'non-usual' combinations should best be tried out on a small project; for a large repetitive project it is best to stay reasonably within the bounds of proven technology!

(a) Metal Decks

Steel and aluminium deck profiles are available in an extensive range which is well known. While they have conventionally been supported over car parks on purlins and beam structures at relatively low pitch giving visually very mundane buildings, they can also, with keen detailing be given life and vitality. They are characterised by straight line geometry and an impression of 'cheap but adequate'. Some big advantages over the other systems are their assured long life and their non-combustibility and resistance to vandalism.

(b) Rigid Translucent Sheets

Typically, such sheets, eg. Glass, Acrylic, Polycarbonate, Fibreglass, are supported at relatively close centres on metal or timber framing, often as isolated skylights and walkway covers. The cost of the finished structures is usually very high compared with a deck roof.

These materials (other than glass) are combustible within the meaning of the Building Acts. Regular maintenance inspections are required of gaskets, sealant, etc. The relatively extensive primary and secondary framing necessary to span over large areas often creates a visually heavy roof belying the intrinsic high translucence.

(c) Structural Fabrics

Experience with these in Australia and New Zealand is now approaching 20 years. Their prime characteristics are continuous curvatures with either curved or straight edges, an ability to be retracted, minimal structural supports and ample spanning capacity for car park layouts. Solar transmittance can vary from 4-15 per cent.

Anchorage points at the structure perimeter often generate significant loads into footings or supporting floor. Like the translucent sheets they are combustible and require annual inspections. This latter is not to be considered a disadvantage, however, since, like windows, the privilege of light translucence brings with it the responsibility of keeping the material clean.

Two generic fabric types are available, one with a nominal life of 15-20 years the other in excess of 30 years.

The cost of completed tension fabric roofs is often about twice that of a simple metal deck roof.

All of the above are 'solid' materials, making them ideal for rain cover. Fabrics provide more than ample translucence for pedestrian activity and car park operation, even without openings, while a whole range of translucence up to full transparency can be achieved with the rigid sheets.

(d) Shade Fabrics

These are coated, open-woven fabrics of lighter weight than the structural fabrics. Conventionally, they have been used as flat panels on frames or supporting cables, however, they can, and have, been used as freeform tension structures over moderate spans suitable for car park layouts.

A wide range of colours and light transmissions is available varying from 30 to 70 per cent. This varies inversely as the tensile strength ie. spanning capacity of the fabric. Some recent projects have seen both shade fabrics and nets used as protection of stored cars from the effects of hails storms.

Because of the perforations in the fabric, regular cleaning (by high pressure hose) is required to maintain a high standard roof.

The anticipated life of these fabrics is between 5 and 10 years, otherwise their general properties are similar to but somewhat less than those of the structural fabrics.

(e) Shade Nets

These vary from woven shade fabrics in that they are continuous knitted nets for which a very wide range of thread and aperture combinations is possible to achieve desired strength and solar transmission values.

Their application and other properties are similar to the shade fabrics.

The cost of complete shade or net structures is very much less than the simplest metal deck roof.

(f) Lattices

These are included as a system because of their simplicity and effectiveness as shade elements. While not at all common in this country they have been used overseas.

The lattice concept is simple, comprising panels of parallel or crossed timber battens supported by a light cable grid.

Alternative materials such as strip water proof plywood, profiled plastics sheets or fabric strips can also be used in regions where the climate signals a need for corrosion protection.

It is anticipated that the cost of a completed lattice shade roof would be about half that of a simple sheet roof. The useful life of such a system would be limited by that of the batten material, eg. 15-20 years for selected timbers.

ILLUSTRATIONS

Some examples of the type of structure systems referred to are included at the end of these notes.

At this formative stage when few open activity areas have been covered in the manner discussed, other than with conventional metal roofing, it is desirable and more likely to achieve a satisfactory result if a solution is developed in its own right rather than merely be a copy of something that has been done somewhere else.

COMPARATIVE COSTS

Some indicators of the cost per square metre of covered area of an extensive shade/roof system have been noted previously and are summarised below:

(a) Metal Deck

• low profile roof on conventional frame	$120/m^2$
• strong prismatic form, wide spans	$180/m^2$

(b) Rigid Translucent Sheet

• FRP substitute for metal deck	$280/m^2$
• Barrel vaults/Polycarbonate	$620/m^2$

(c) Structural Fabric

• Repetitive free forms, moderate span	$200/m^2$
• Free-standing framed	$240/m^2$
• Non-repetitive special design	$310/m^2$

(These are for PVC/polyester type fabrics. Teflon/glass fabrics may cost up to 50% more)

(d) Shade Fabrics

• Flat sheet on frames	$120/m^2$
• Flat sheet cables	$ 40/m^2$
• Free-form shapes	$220/m^2$

(e) Shade Nets

• Flat profile on cables	$ 30/m^2$

(f) Lattice

- Low profile, wood battens on cable net $ 70/m²

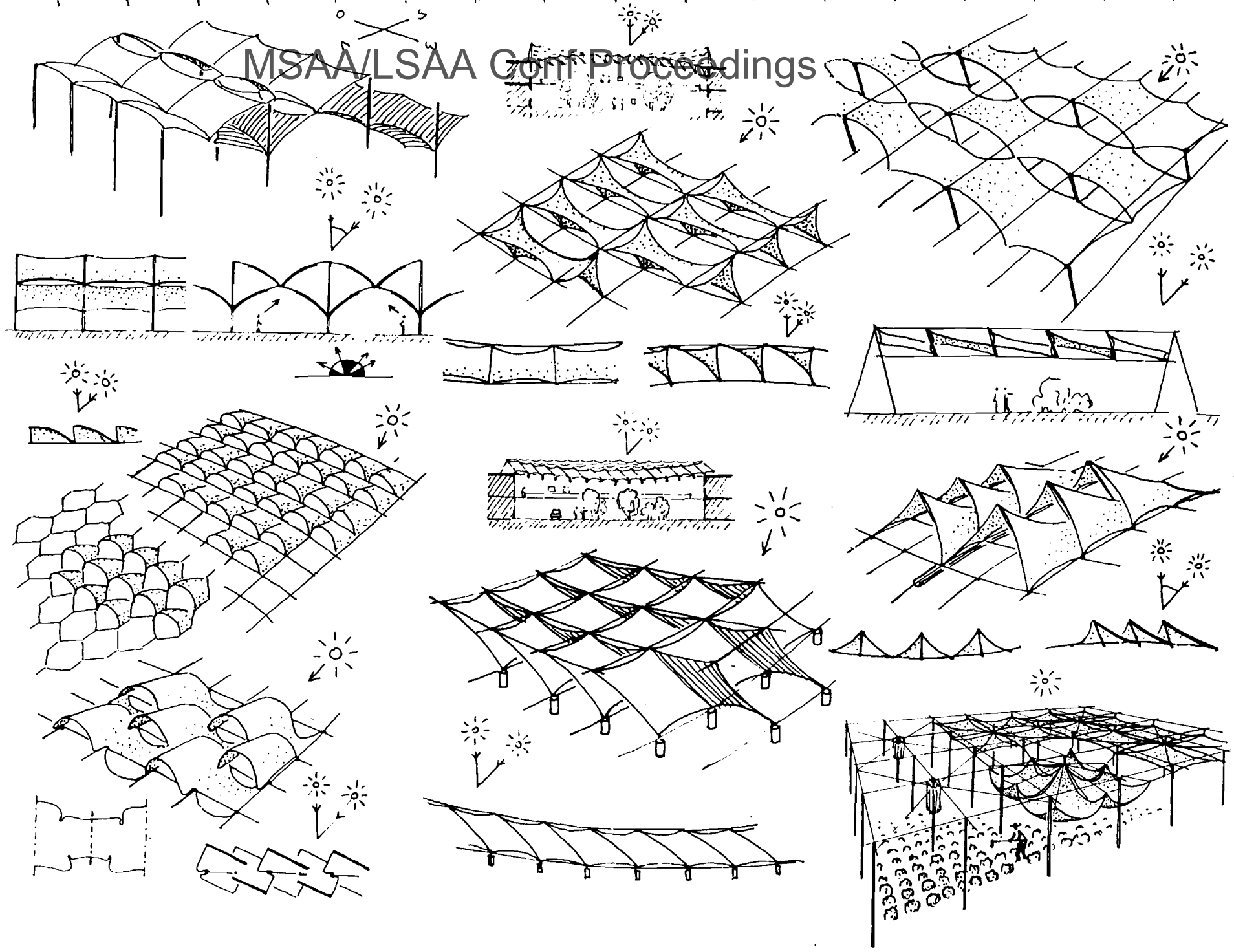
CONCLUSION

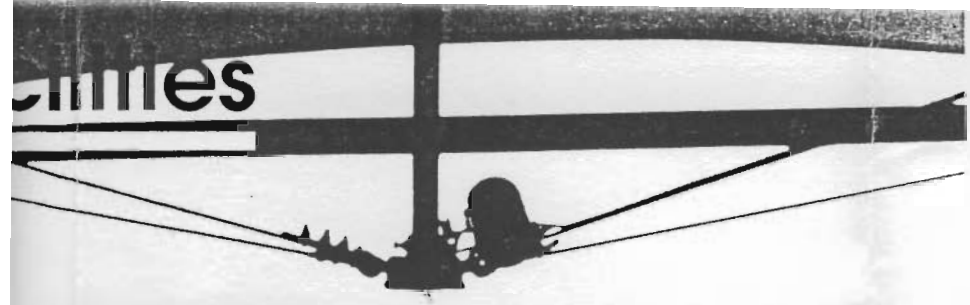
Roofing of car parks, playgrounds and open public areas primarily for shade is a new endeavour. There is strong evidence that our society's perceptions will soon make it a desirable facility for both public and commercial developments wishing to compete successfully.

A range of construction systems and materials is available to allow effective roofing, their costs ranging from exceptionally low to very high. At the lower end the additional costs to a major project of providing such shading is not at all excessive.

An overall design regime in which walkways, building entries and some key areas are rain protected, parking bays sun protected and roadways and aisles left open has much to commend it. Combining such structures with extensive soft landscaping will add greatly to user satisfaction.

At this stage there are few actual local examples to which one can refer, so that the first successful projects will demand a rational development of ideas tempered by cost/benefit analyses and an eye to what may well be deemed essential to the use public of the mid 90's.





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2. Bus terminal
3. School car park
4. Bicycle rack covering
5. Carpark, Saudi Arabia
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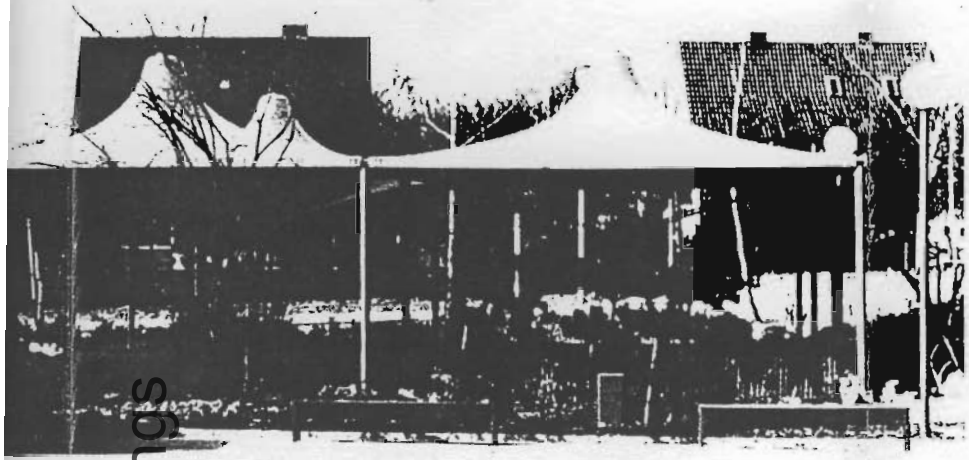

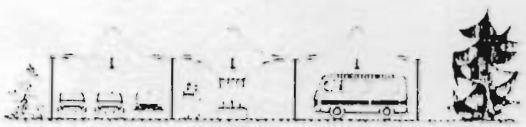

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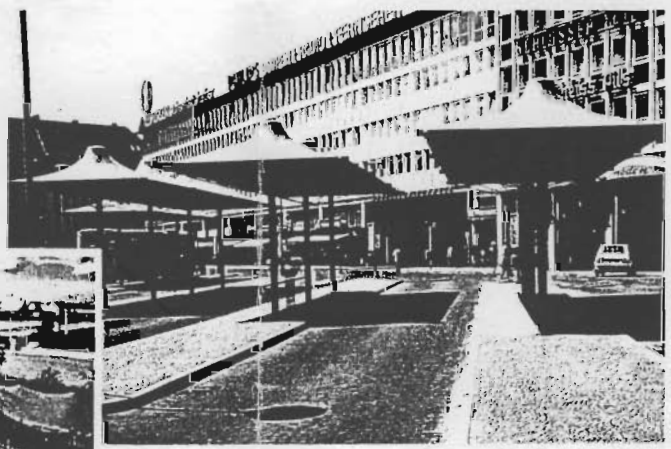

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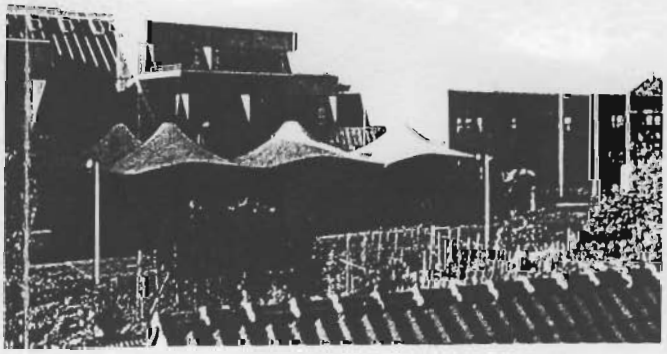

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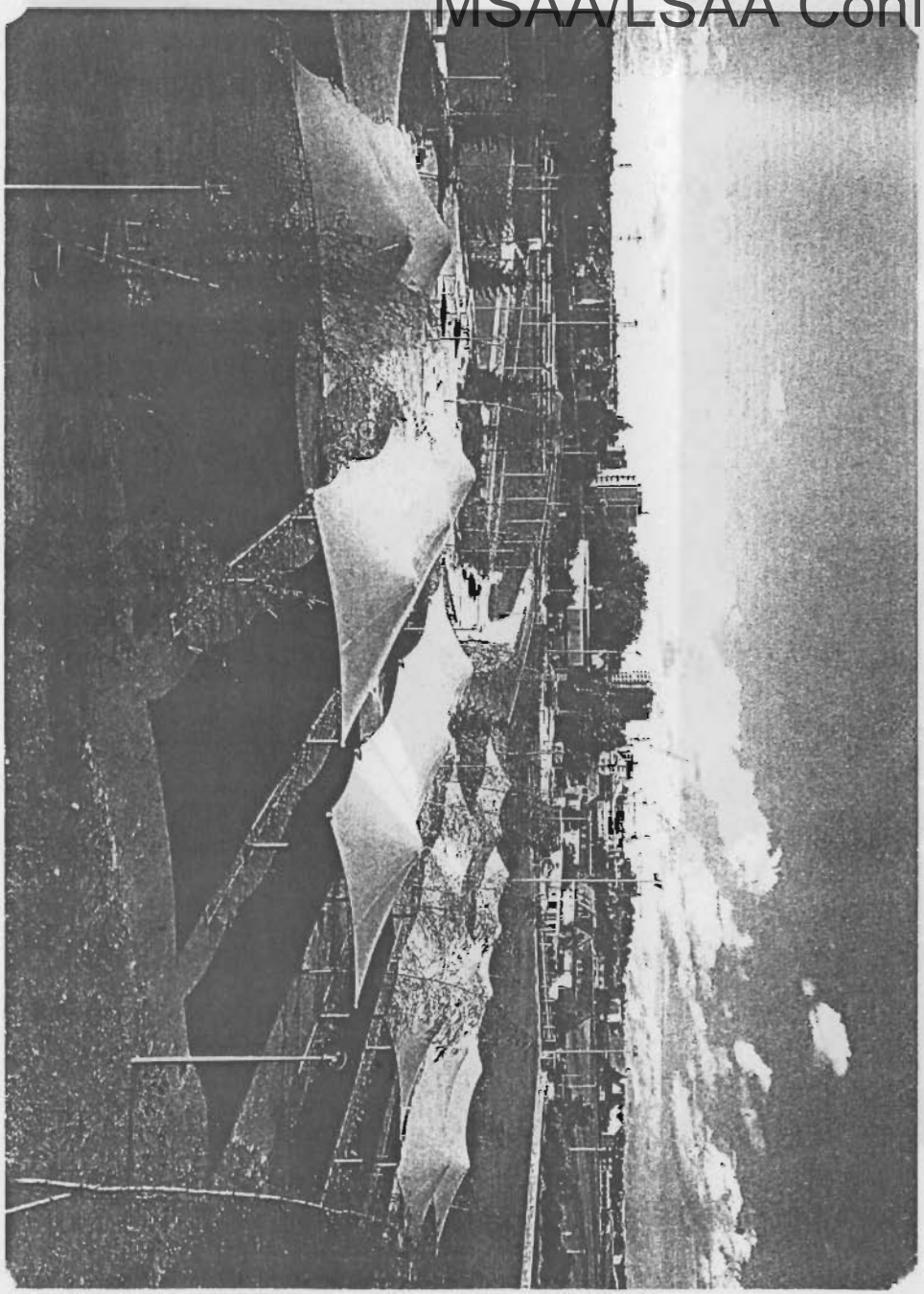
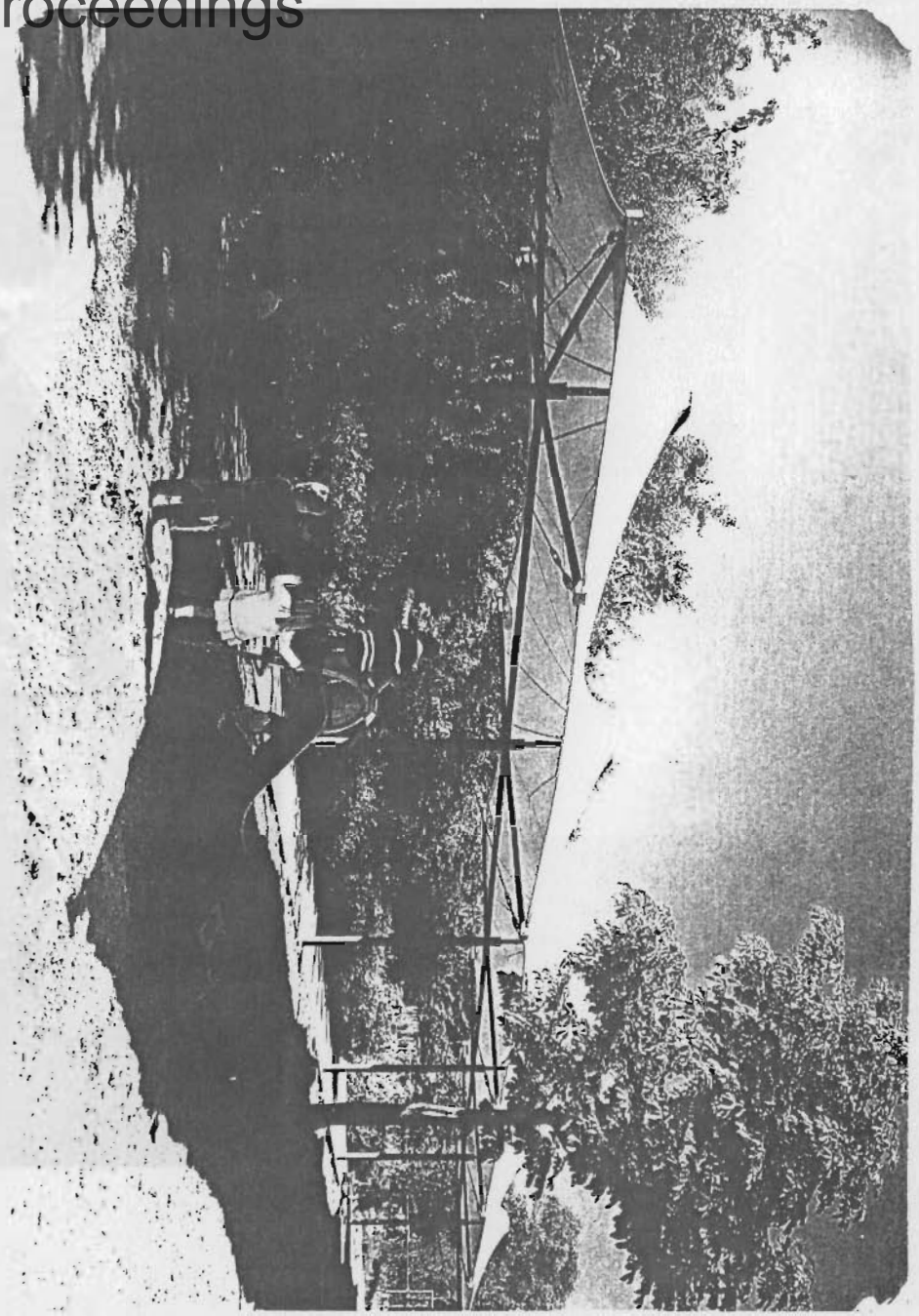
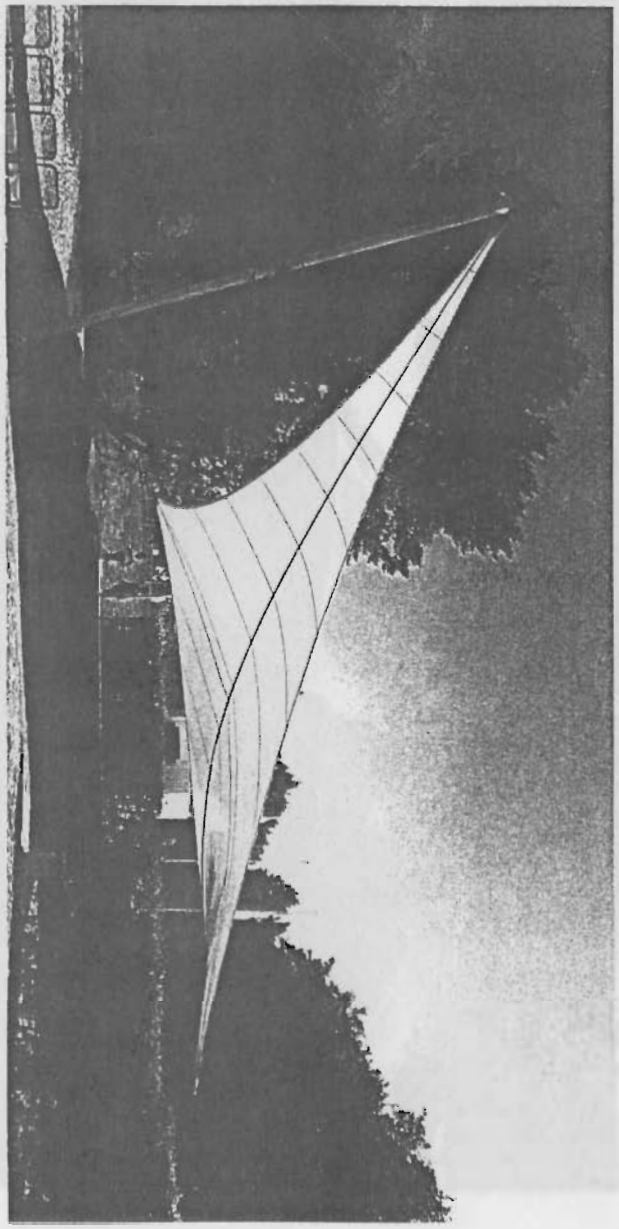
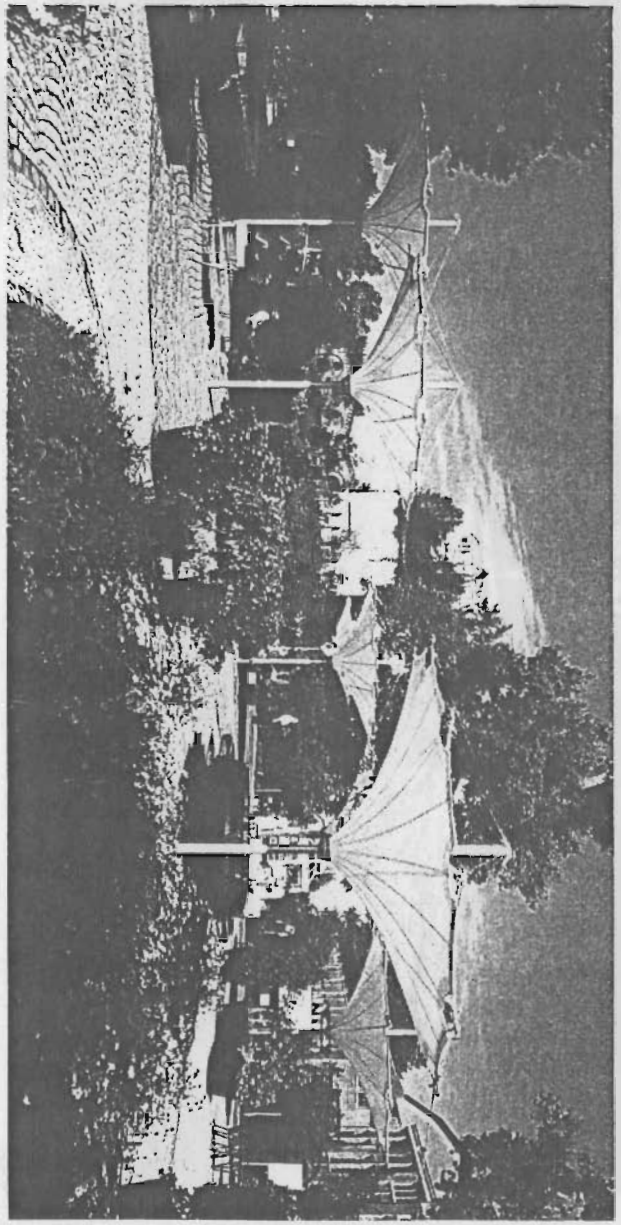
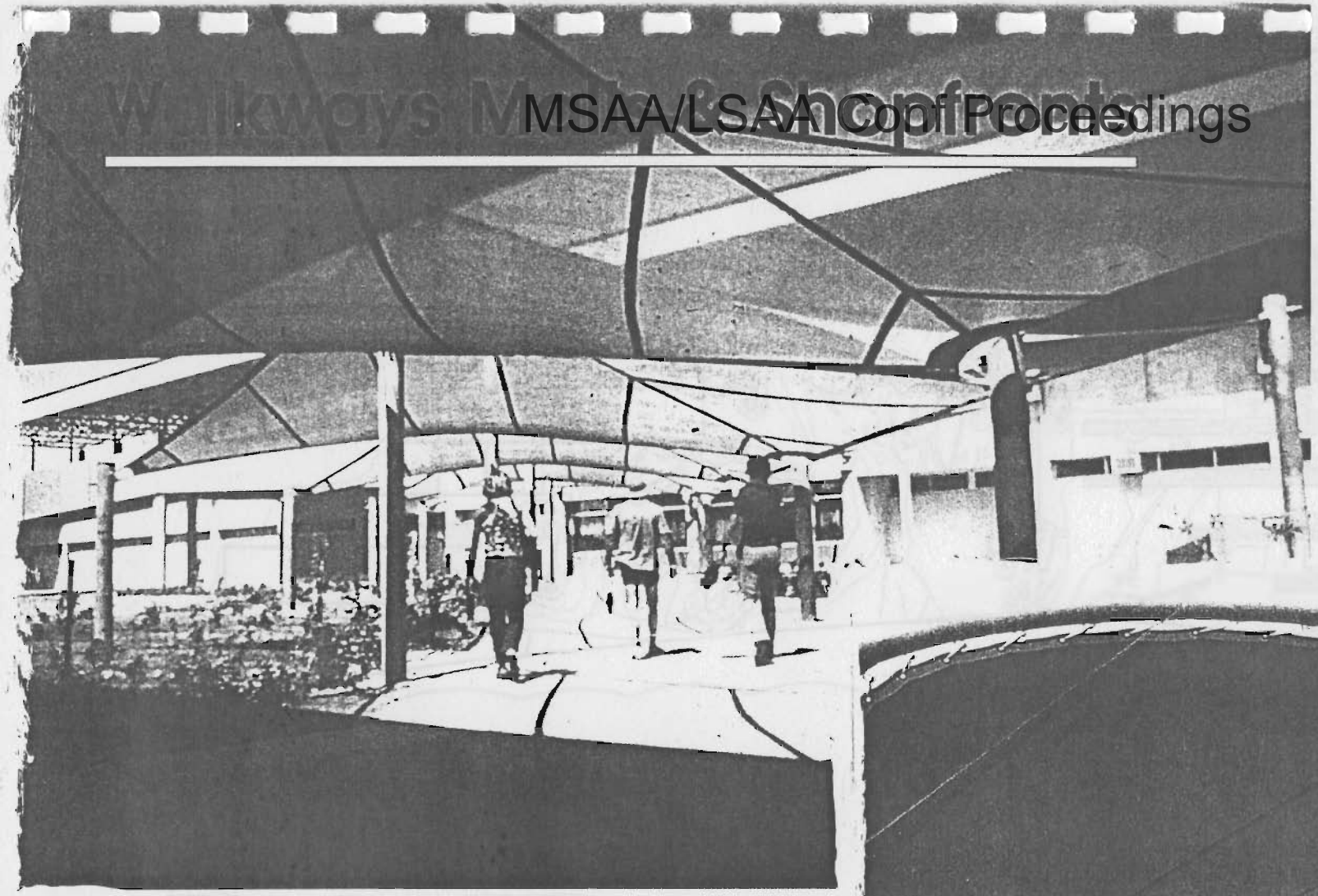


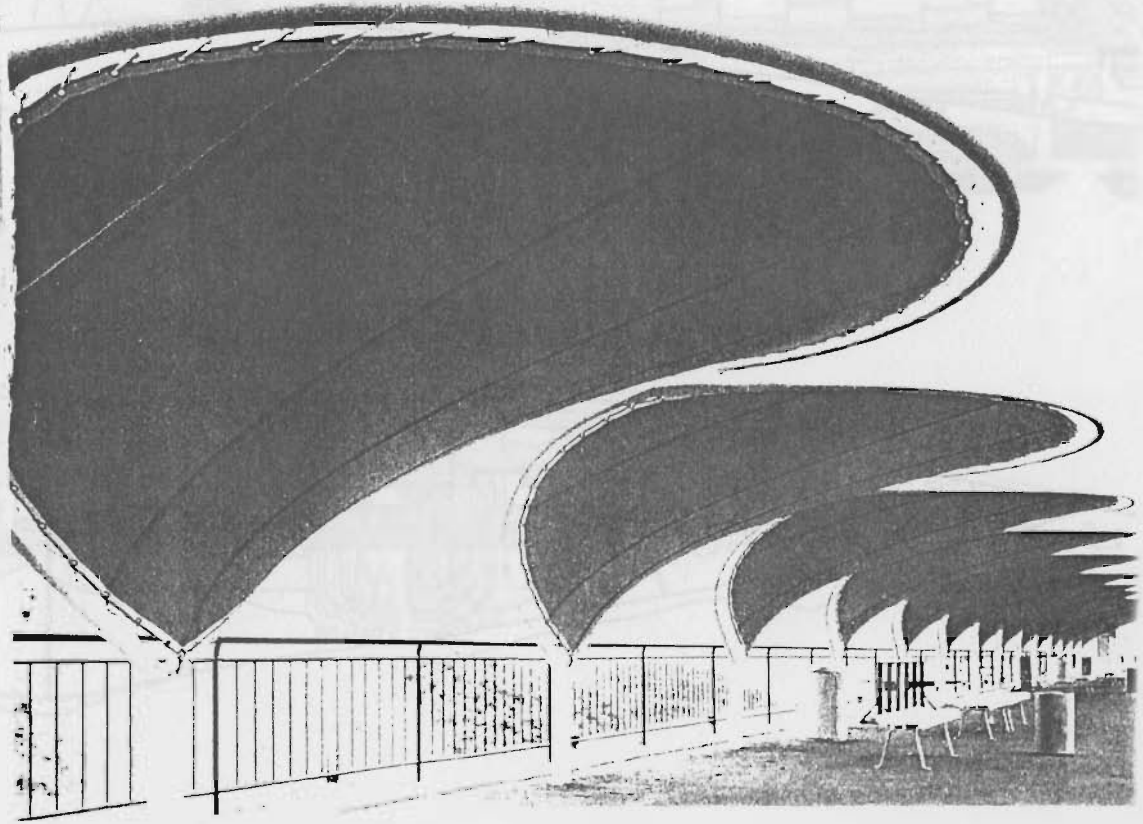


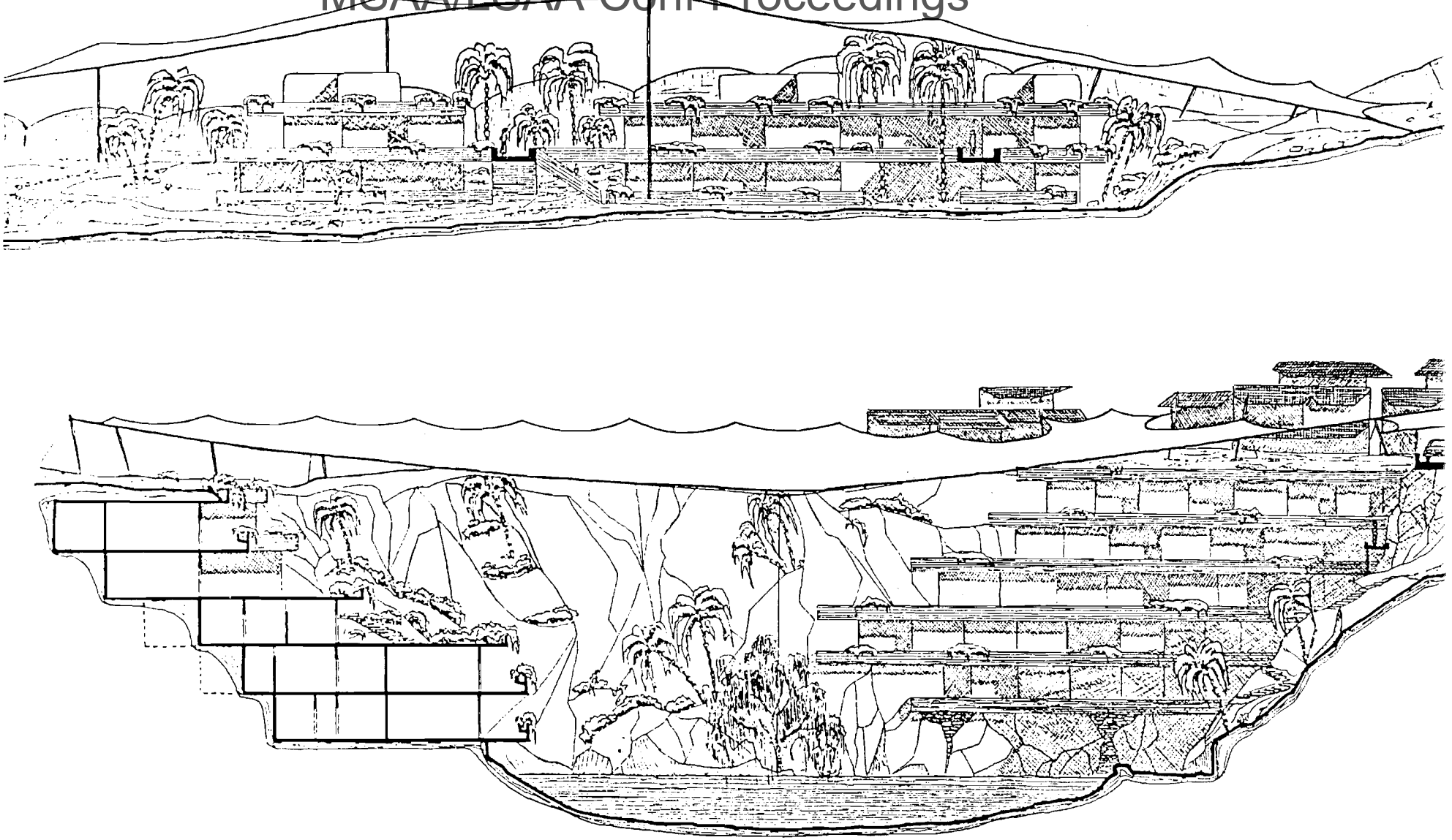
MSAA/LSAA Conf Proceedings

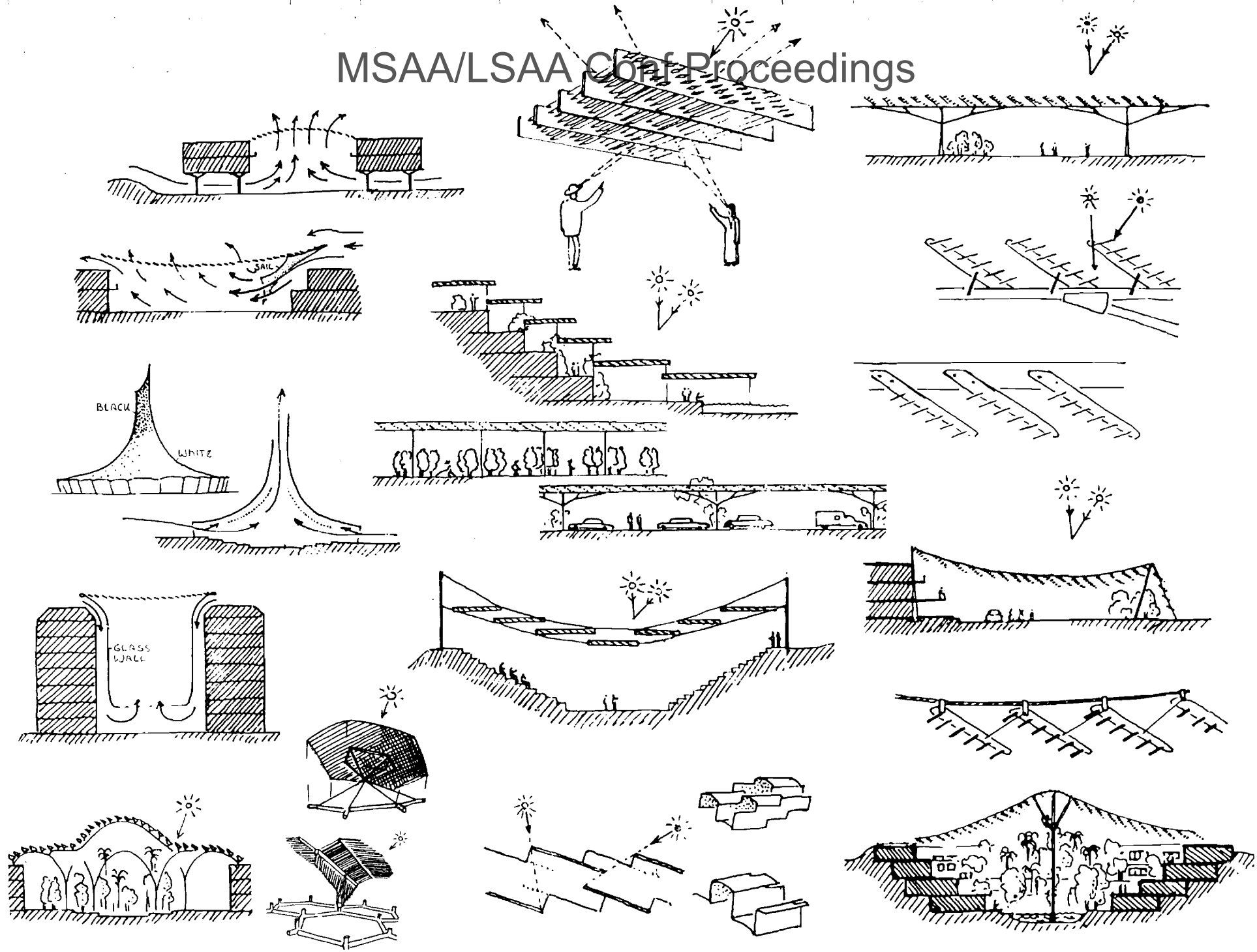












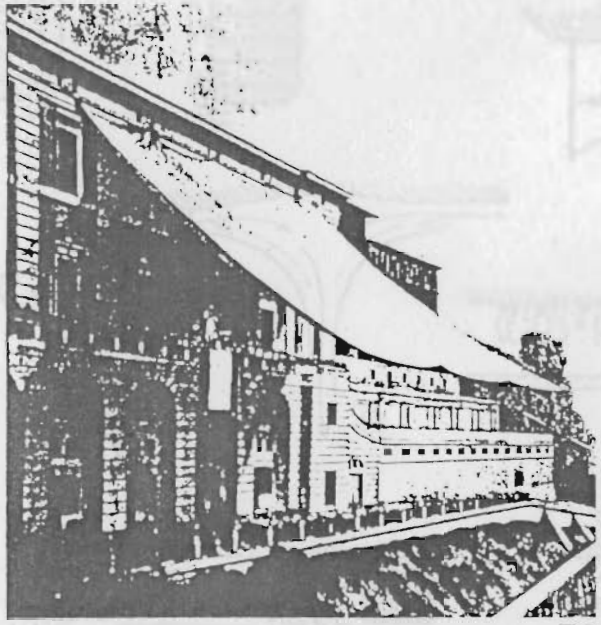
SONNENSEGEL UND THEATERZELTE VON DEN RÖMERN BIS HEUTE

Nachdem die Zeit der römischen Theatervela vorbei war, wurden aber immer noch Zeltdächer und Sonnensegel gebaut. Doch es wurde bisher wenig darüber berichtet. Es ist unbekannt, ob es eine Entwicklung gab. Das Gemälde eines Sonnensegels über einer Theaterbühne, Verona 1772 > GT 123.2, läßt in verblüffender Deutlichkeit Einzelheiten erkennen. Weitere Bilder: Markise > 1, Papstbesuch in Taormina, Straßensegel > 2 und 3, Zirkuszelt > 4, Sonnensegel aus Holzgittern > 5, Konferenzzentrum in Mekkah, gebaut 1970.

AWINGS AND THEATRE MARQUEES FROM ROMAN TIMES UNTIL TODAY

After the period of the Roman theatre Vela had passed, tents or marquees and awnings continued to be built. There is, however, very little written documentation. It is not known whether any development took place in this field.
The painting of an awning above a theatre stage in Verona 1772 > GT 123.2 shows details with an astonishing clarity. Further illustrations: awning > 1 - the Pope's visit to Taormina; street awnings > 2, 3; circus marquee > 4; sun shades consisting of wooden lattice > 5 (conference centre in Mecca, built 1970).

△ GT 123.2



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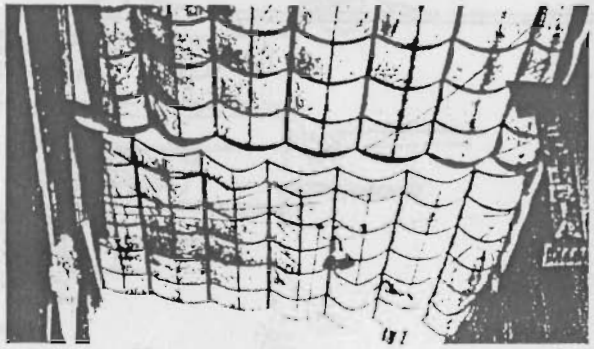

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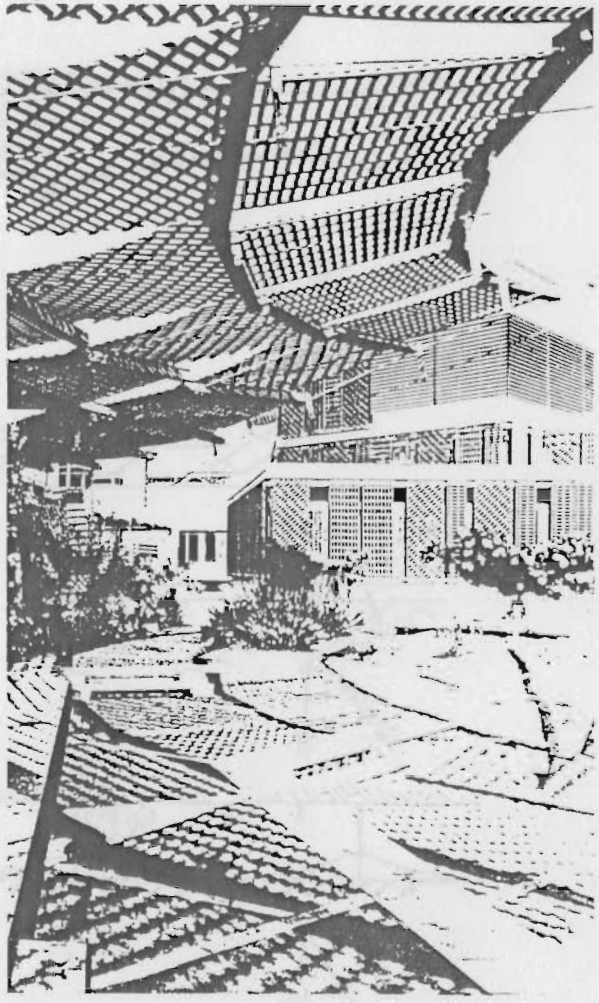

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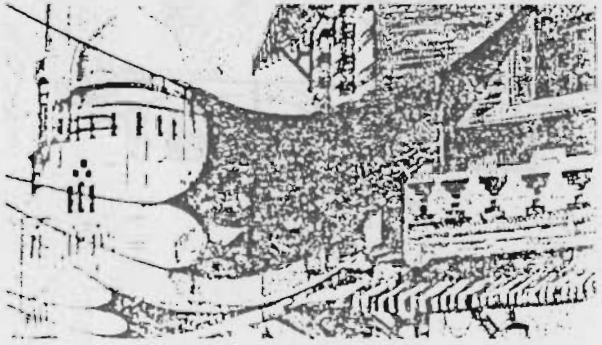

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