

The Characteristics of Low Energy Consumption Buildings in Hot-Dry Climate

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Abstract Text:

The attributes of the building's volume and exposure areas play (perform) a major role in establishing the character of Al-

Madinah's traditional fabric in the hot, dry climate of Saudi Arabia.

Abstract

Nowadays it is beneficial to look for energy-conscious procedures for building design, which assists in reducing energy consumption. The buildings' fabric should be efficiently designed to meet electrical demand to reduce the impact energy usage has on the people. Hence, this act will contribute to environmental health.

The emphasis therefore to build better architecturally and environmentally creative designs is heightened. It is worthwhile to develop conscientious design techniques and framework guidelines to work to benefit everyone, along with stringent rules to govern energy conservative building codes.

Designers and builders expend significant effort to ensure buildings use as little energy as possible. As urban and suburban areas spread out, the cost to travel increases. Among the goals of these developmental paradigms are communities, towns, and urban areas that are pedestrian-friendly and accessible, with minimal use of the automobile. Cities should be designed to meet everyone's environmental preferences and notions of environmental quality. Decisions about constructing buildings and

towns and their spatial distribution are the key to creating a future built upon a sustainable developmental concept.

Window area construction should provide the required level of daylight and minimize the heat transfer by conduction and solar radiation between the outside and the inside. Also, walls and roofs should have the ability to delay the flow of heat to buildings. The thick walls were built and narrow arteries emerged resulting from the need to minimize the effect of solar radiation intensity on vertical as well as horizontal surfaces. All these gave a proportional sense to overcome the impact the summer heat exchange had outside and inside of buildings.

The traditional compact layout came as a result to overcome the impact of intensity from irradiance load. Reducing surface exposure from the sun, radiation does not mean to return to compact architecture style but to make or predict a comparison between solar altitude between the winter solstice at noon and the angle profiles. This will help to find the proper ratio between the street width (W_{st}) and building height (B_h).

Key words: conscientious ,irradiance load, procedure, spatial distribution, sustainable.

Objectives:

- 1- Reduce environmental stresses
- 2- Provide access to social places
- 3- Increase connection to nature
- 4- Encourage the habit of walking in the community

Methods of Assessment

a- What is the surface resistance of a building construction in a hot-dry climate?

The surface resistance of a building construction in hot-dry climate is given using the mathematical calculation to find the proper values.

b- In what degree is it possible to minimize the window area?

Windows should be designed to the degree of allowing the required level of daylight in to minimize the heat transfer.

c- Why is it important to reduce the exposure of sun radiation?

The heat load in summer is intense. Therefore, the appropriate process reduces the heat load to the building during the summer.

d- How do traditional buildings meet climate output?

Traditional buildings were not built randomly to fit particular individual tastes. Hence, there must have been a rule or a formula or pattern that architects or builders used and these were handed down from one generation to another.

e- What is the procedure used to harness solar power?

Solar energy, radiant light and heat from the sun is harnessed using a range of ever-evolving technologies such as solar heating, solar photovoltaic, solar thermal, solar electricity, solar architecture and artificial photosynthesis.

Introduction

The Physical Location of Al-Madinah

Al-Madinah is an oasis surrounded by mountains and lower hills of black basalt (Lava). It is situated in Hidjaz on a plain, sloping very gently toward the north. It is on the trade route, the '*incense road*.' It is rich in water resources and has fertile soil of salt, lime and loamy clay.

Traditional Architecture Fabric

Al-Madinah's traditional architecture fabric has been developed through different historical periods. It possesses a characteristic unity, in response to climate and cultural identity. It is the interaction between the man and his environment (Hassan Fathy, 1977).

Development of Islamic housing design inside to outside, interior to exterior is a fundamental concept of traditional Islamic cities.

Compact, close building layouts are a notable characteristic of traditional Islamic cities, from the Atlantic Ocean to the Arabian Sea and to Samarkand, see figs. (1-4).

Elements of Climate Control

Building materials were responsible for thermal efficiency, performance and climate control such as walls, roofs and windows. Heavy load bearing walls, thick roofs and ceilings from brick adobe (mud brick) or stone are poor conductors of heat and are therefore particularly suitable for arid regions.

In addition, thick walls and roofs contribute to the extended transfer of solar radiation lag time. Five other elements are used to modify the climate, mainly by controlling air circulation:

- 1- The water fountains,
- 2- The Shukhsheikha (air shaft and sky light),
- 3- The Malkaf (wind catcher),
- 4- The Mashrabiya (projected windows), and
- 5- The Roshan (flat windows)

The first three elements served together as an entity, especially in summer.

Decisions regarding the development about buildings, towns and their spatial distribution are the key for creating a future built upon the sustainable development concept. There is a clear connection between resource use, economic

growth, and environmental restrictions. To choose to ignore the situation is perilous. This connection is clearly defined as sustainable urban areas, see fig. 5.

Modern architecture intentionally defies its older neighbors rather than stand beside them in peace. For that, children will hardly be able to find a safe communal, traffic-free place if the approaching gridiron plans for architecture move forward in the future. If the current urban design scheme for land use continues, 'heat-island' will soon be created, the result of using gridiron patterns with wide boulevards and extensive areas of concrete and asphalt.

Method of Investigation

The investigation method of this paper is based on literature review of available data and use of comparative and analytical study. It is therefore beneficial to acquire these techniques to reach the proper results.

Comparative investigation: There are several conflicting factors about how to produce the required urban form. These factors are climatic, social, economic, technologic, environmental, political and psychological; all will affect the urban form to emerge.

The characteristics of low consumption buildings

Two types of city plans were investigated.

1- The common scheme all over the Kingdom of Saudi Arabia despite the climatic variations is the gridiron street patterns, see fig. 6, the street front patterns where the building units, houses, rows or apartment towers line both sides of a street. Access and orientation are easy and there is little ambiguity in the plan. The primary task of this approach has been identified by geometrical grid. Vehicular circulation systems become predominant and dominate the planning regulations of land subdivisions. Subsequently urban form

identifying buildings and blocks have become street-oriented communities and isolated from each other.

2- Court community layout based on blocks with interior courtyards. This module is the court arrangement in which group units face inward to a common open space. It produces an independent place secure and well identified. This kind of planning method is good for social and visual reasons to encourage neighborly relations, to prevent strangers, and provides a pleasant living space. Car parking locations are at the corners and between blocks, see fig. 7.

In the table below the comparative study is drawn from a number of factors:

Table 1

S N	Factor	Grid-Iron pattern	Court community
1	Social and children's communal places	Less social and sometimes without children's play areas.	It is mainly designed for social and visual reasons. Communal gardens emerge.
2	Traffic and air quality	More cars circulating lead to air pollution, with more restrictions on people's mobility.	Less traffic will reduce the emission of gases. It is oriented for pedestrian and vehicular segregation without placing unnecessary hindrance on people with mobility. For some occasions, vehicles are allowed to enter the court.
3	Built up area solid and void	The gridiron patterns lead to approximately 60% of streets and 40% of developable areas.	More area is for land to develop, 80-88% for development and 16-20% for street development.
4	Number of units in Hectare	Less units not exceeding 20 units/Hectare	More units could reach to 40 units/Hectare
5	Cost of pavement and infrastructure	More roads to be paved and more infrastructures installed, which means more money will be spent on this unnecessarily.	Reasonable roads contribute less to unnecessarily spreading of infrastructure.
6	Irradiance input and energy consumption	This kind of plan leads to open geometry, conducive to air pollution desperation and solar access. That means more heat will be transferred to buildings for more energy consumption.	This kind of plan leads to compact layout with less exposed areas to solar access. Heat transfer to buildings will reduce. It is contributing to reasonable energy consumption with improved air quality.

The characteristics of low consumption buildings

A study was conducted using a mathematical model to find the relationship between the overall form of building in a hot-dry climate and the solar radiation it receives. The aim is to find which area appropriate to an historic city and which minimize the solar heat gain in the buildings and in surrounding streets. This procedure was used:

- a- Examine the climatic and geographical features of a particular site (Al-Madinah in Saudi Arabia).
- b- To make a number of case studies calculating the incident solar radiation on the city blocks of different forms.

In this study one case had been chosen, the building and street, the external and the internal spaces are considered a single physical system. Solar radiation works as a source of excitation on the system. The choice of the materials and geometry of the external subsystem determines the primary input. Minimizing the areas of external surfaces exposed to the sun's radiation reduces the input to the internal subsystem. The thermal mass and insulation in the system determine the time lag. The impact of solar radiation is reduced when the built form is compacted to give a high ratio of volume to surface area, when there is mutual overshadowing of blocks, and when the form of the blocks minimizes the area exposed to the sun. Isolated single buildings have a large exposed area in relation to their volume, see figure 8.

Conclusion

The most fundamental element for the realization of equilibrium between buildings and nature is a building's function. Therefore, perceiving the nature and behavior of traditional fabrics and buildings, the choice of design made in construction and the way traditional fabric and buildings relate to their environment will make the difference in the buildings solar efficiency.

It can therefore be concluded that the daily total irradiance incident on the urban canyon vicinities in hot-dry climate is an important factor to exert influence on building and street construction due to its intensity and health-giving

properties. From calculation and graphs, it has been found that the streets that run **E**—>**W** and buildings that run **N**—>**S** is an optimum orientation for urban form of Al-Madinah city.

It can be concluded that building proximity will control the effect of the irradiance incident on building. With a ratio smaller than one, compact form will emerge, which is more suitable for the climate of Al-Madinah City. With a ratio equal to one, balance will be achieved between irradiance incident and heat admittance. With ratio bigger than one ($W_{st}/B_H > 1$), climate hostility will be increased and therefore more areas exposed to heat load. Additionally, the flow of the wind movement will be increased.

Therefore, for sustainable urban design to be achieved we should look for environmentally responsive buildings. It is a design strategy to look to the building as a whole unit. Hence, creating buildings that use less energy not only reduces and stabilizes costs, but also reduces environmental impacts.

The landscape of the roads and cities could significantly reduce heat and temperature and air pollution. Therefore, it should be recommended to conserve and increase the greenery within an urban area. A communal garden for small children to play safely free from traffic is recommended.

Figures:

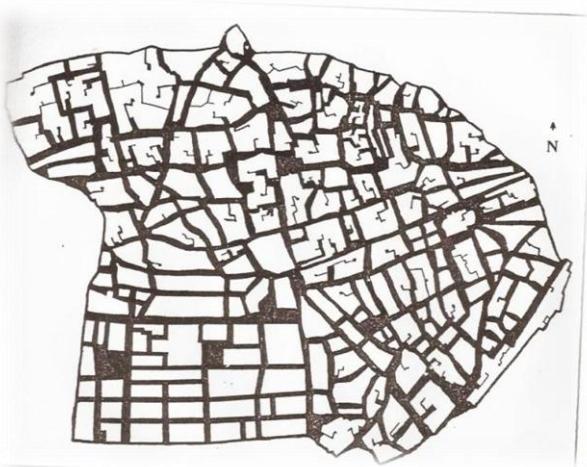


Fig. 1 shows the compact layout of Seville (Spain), southwest of the city, partial plan, Christian sector on extreme southwest (Francois 1980)

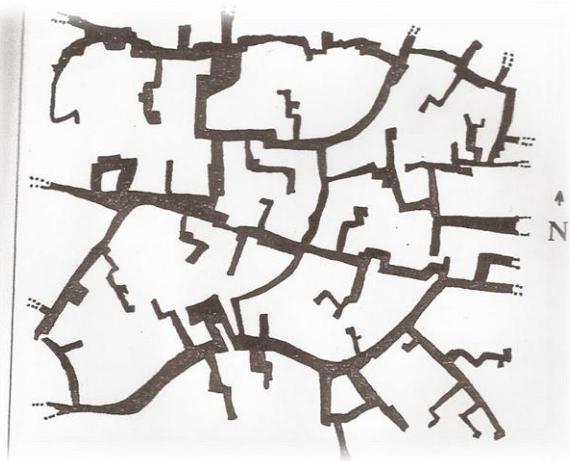


Fig. 2 shows a partial plan of the original city of Samarkand (USSR), now CIS.

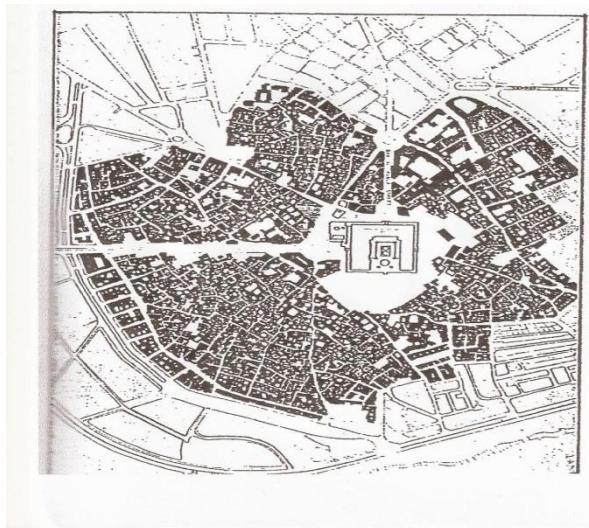


Fig. 3 shows map of Baghdad Iraq, which illustrates the old layout and new streets tear this structure.

The characteristics of low consumption buildings

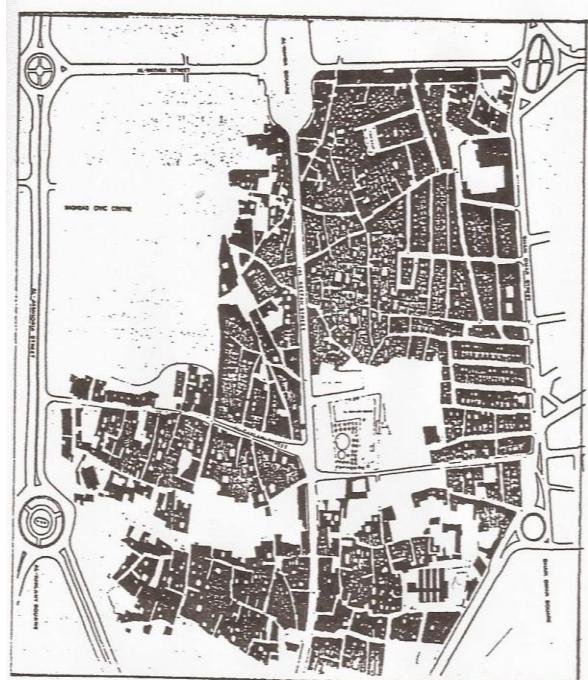


Fig. 4 shows a traditional layout plan of Al-Kadhiyeh, one of four historic cores of Baghdad, (Warren 1982)

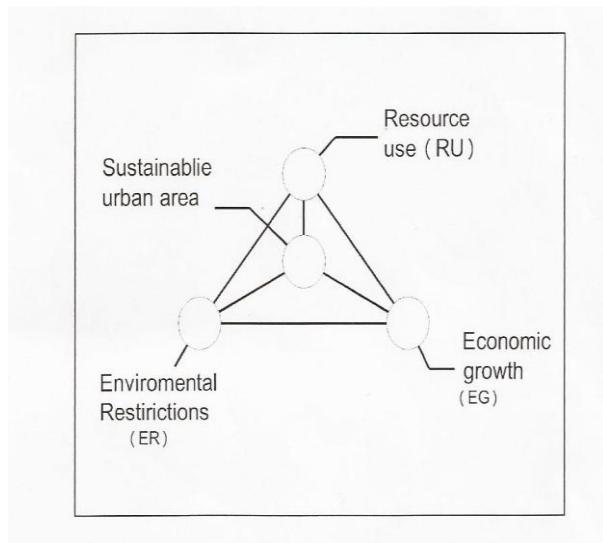


Fig. 5 illustrates the connection among resources used, economic growth and environmental restrictions to define a sustainable urban area.

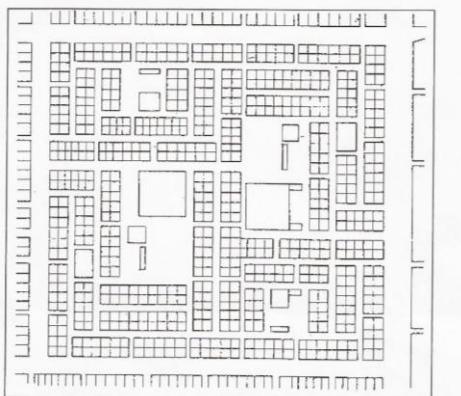


Fig. 6 illustrates the common urban design pattern all over the KSA. It is a part of urban planning .

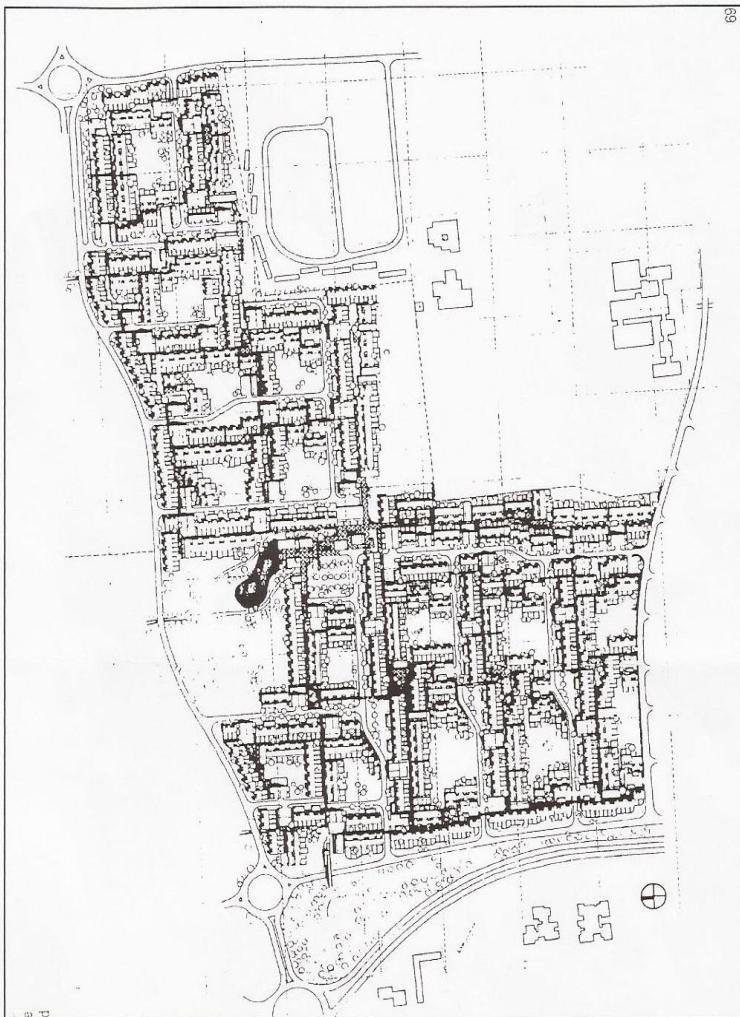


Fig. 7 shows the court community, urban design pattern **Basildon New Town, Ohio State U. S. A.**

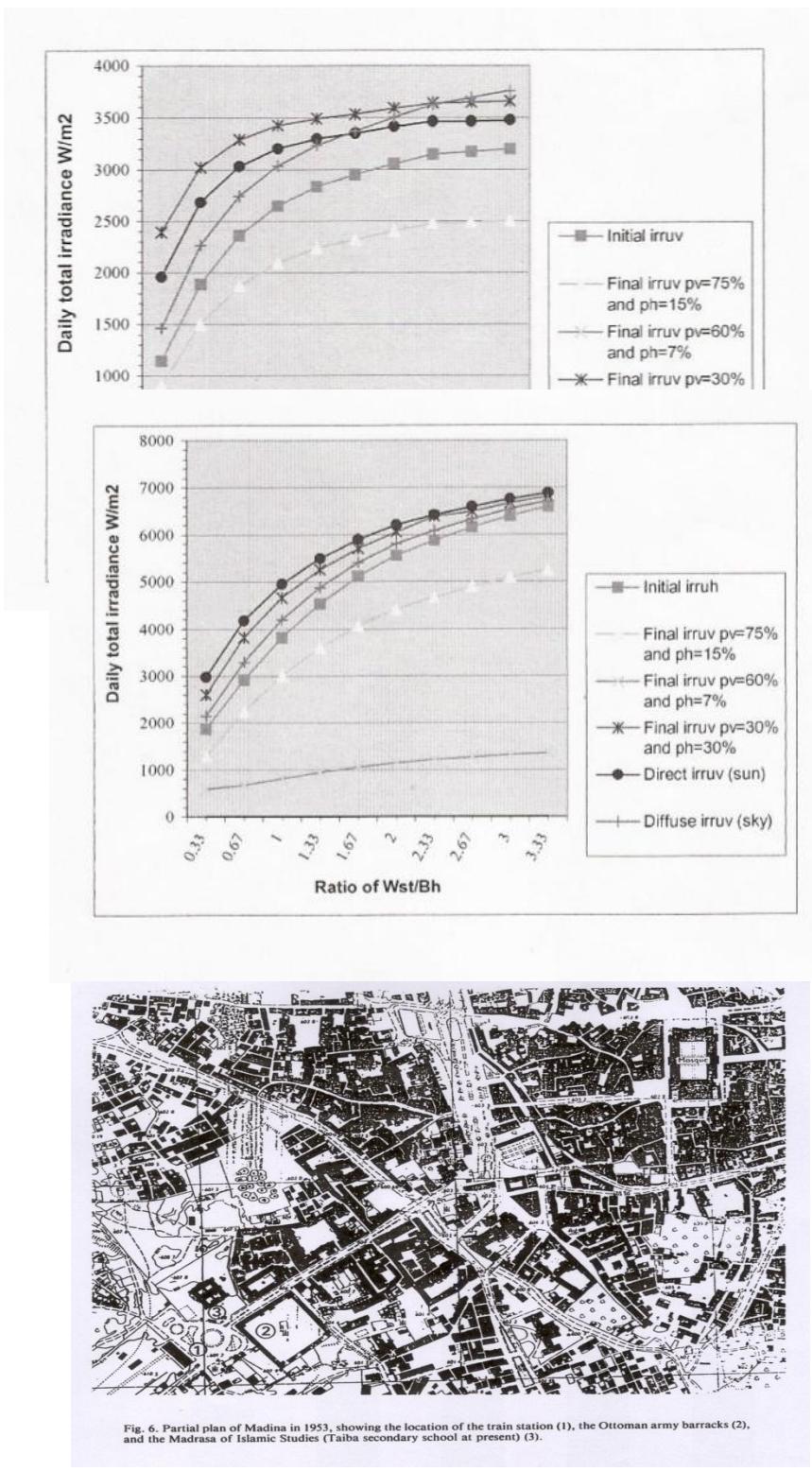


Fig. 8-a is a daily total irradiance incident on horizontal surface at an urban canyon on 21 July. The street runs N---<--->---S.

Fig. 8-b, daily total irradiance incident on east elevation at an urban canyon in July. Street runs N---<--->---S.

Fig. 9, this layout represents AlMadinah traditional planning

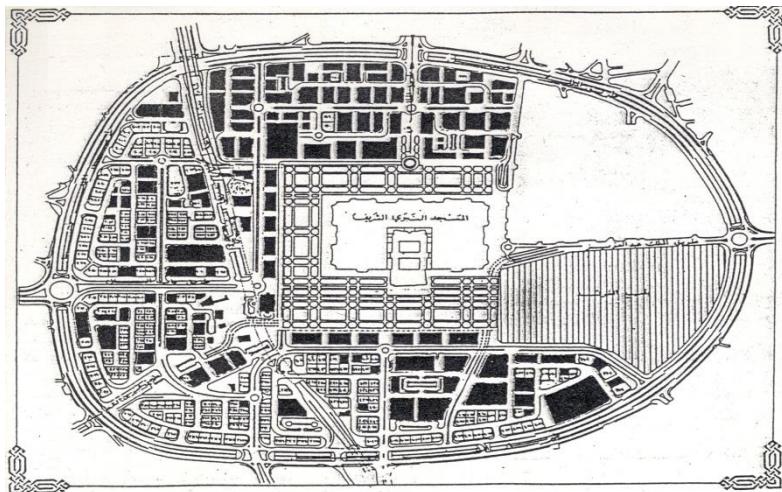


Fig.10, this layout the modern planning after the demolishing the traditional fabric.

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