بسم الله الرحمن الرحيم

MONA MAGHRABY

شبكة المعلومات الجامعية

التوثيق الالكتروني والميكروفيلم

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شبكة المعلومات الجامعية

التوثيق الإلكتروني والميكروفيلم

جامعة عين شمس

التوثيق الإلكتروني والميكروفيلم

قسم

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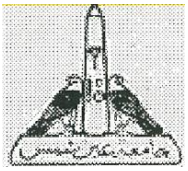

Faculty of Engineering
Department of Architecture

Developing Wide-Span Building Techniques by Using Low Cost Traditional Date Palm Midribs Bundles

A thesis submitted in partial fulfillment of the requirement of Ph.D. in Architecture Engineering

By

Eman Atef Abdulaziz Darwish

M.Sc. Architecture, Faculty of Engineering- Ain Shams University-2017

Supervised by

1- Prof. Yasser Mohamed Mansour
2- Prof. Hamed Ibrahim Elmously
3- Prof. Amr Ali Abdelrahman

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Examiners' Committee

Name and Affiliation	**Signature**
Prof. Mohammed Moa'men Afify Department of Architecture , Cairo University	…….
Prof. Mostafa Refat Ismael Department of Architecture , Ain Shams University	…….
Prof. Yasser Mohammed Mansour Department of Architecture , Ain Shams University	…….
Prof. Hamed Ibrahim El-Mously Department of Design and Production , Ain Shams University	…….

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Researcher Data

Name	**:**	Eman Atef Abdul-Aziz Darwish
Birth Date	**:**	6/2/1993
Birth Place	**:**	Cairo, Egypt
Academic Degree	**:**	M.Sc. in Architectural Engineering, Faculty of Engineering, Ain Shams University, Cairo, 2017. Specialty: Building Technology and Environmental Studies. B.Sc. in Architectural Engineering, Faculty of Engineering, Ain Shams University, Cairo, 2014. Grade: Excellence with Honor, Top of Class.
Current Occupation	**:**	Assistant Lecturer, Department of Architecture, Ain Shams University

Summary

Approach

Date palm midribs, among the other secondary products of date palms, have been used as a source of raw materials for traditional handicrafts and construction in rural Egypt. This technical heritage was built upon various techniques that are still actively practiced among a wide base of workers.

Literature review

This surviving technical heritage encouraged previous trials of using date palm midribs in building 1:1 mock-ups to investigate the potential of using date palm midribs in wide-span construction using low cost traditional techniques. This approach depended on imitating the spontaneity of the traditional workers. However, the on-site behavior would differ greatly from the predicted behavior because of the existence of unintended factors such as wind loads. Another approach employed the axial loading nature of trusses in achieving high structural efficiency of the midribs. This analytical approach depended on structural experimentation and analysis of the designed structures. However, the intricacy of the developed joinery of those structures obstructed the future developments of the designs due to their complexity, which consequently increases the building materials cost.

Question and argument

Here the thesis raised the following argument: What is the actual potential of date palm midribs in the field of wide-span construction? Can a fusion between the analytical and the spontaneous approaches unlock those potentials while sustaining simplicity and efficiency that are among the main demands of the market? Thus, the design of the tri-arched space truss was introduced.

The design of the tri-arched space truss merged between the curved shape of arches that matched the natural bent shape of the midribs and the structurally form-active shape of space trusses. The design depended on the simple traditional techniques of bundling and rope-fastening while employing the parabolic shape in order to host simple friction-based joinery. The development of this design was guided by the three fundamentals of architecture as stated by Vitruvius; Utility:

Utilitas, Durability: *Firmitas* and Beauty: *Venustas*. The design was validated experimentally and evaluated according to the market needs.

Findings

The finding of the thesis can be summarized as followed:

1. Date palm midribs was employed in the design of a wide span structural system while keeping the peripheral layer on the midribs in order to minimize the cost of pre-processing and make advantage of the superior mechanical strength of the peripheral layer while compared to the strength of the transitional and core zones.
2. The design of tri-arched space truss (TAST) was proposed as the most suitable form active design for date palm midribs light wide span construction to achieve high structural efficiency. The parabolic arched truss chords depended on channeling axial compression mainly along the vascular bundles of the midribs and allowed to fix the bracings into the bundles using simple and flexible friction based joinery.
3. Specimens were built using limited number of prototypes by three local carte workers in fast and simple procedures, which indicated high productivity and reinforced the reusability of the specimens' elements. The specimens were tested experimentally and the structural behavior was found to be highly flexible with gradual and steady failure in specific portions which allowed for the reusability of the rest of the specimens. The long-term effects on the specimens were investigated and were found to be minor.
4. The mechanical properties of date palm midribs were verified and a Finite Element Method (FEM) model was validated to predict the full scale behavior. 12m span TAST was found to be safe under own weight, wind load and roofing.
5. The TAST was implemented into several form active structural arrangements to host the functions that are allowed by the Egyptian code of fire protection. The structural analysis of the tensile fabric saddle vault and the braced barrel vaults showed to be safe covering the span of 12m under own weight, wind load and roofing.
6. The primary cost analysis of the raw materials of the TAST braced barrel vault indicated higher cost-efficiency than standard steel trusses, which makes it valid to propose using the TAST structural arrangements in

various practical applications such as school playground sheds, markets, workshops, garages and multi-purpose halls.

7. The designs of the TAST-based structural arrangements succeeded to sustain the nature of the used materials, which allows for various options for reusing and recycling after the end of the service life of the buildings.

In conclusion, the developed TAST component, an output of the targeted fusion between traditional spontaneity and analytical efficiency, employs date palm midribs in wide-span construction arrangements that merge between the cost-efficient traditional construction, structural efficiency and high productivity, for the sake of empowering the rural society in Egypt.

Recommendations

The developed date palm midribs tri-arched space truss consists of standardized elements that can be prefabricated, which allows the design to be replicated for mass production with reduced overall costs. Therefore, this thesis recommends that the decision makers can make advantage of this design to solve the problem of the lack of shaded areas in the poor rural areas in Upper Egypt. In addition, this thesis opens the door for the following fields of research; including: the impact of the outdoor environmental conditions on date palm midribs mechanical properties, the design of the overlapping area in making longer date palm midribs bundles. In addition, research is encouraged to study foundation details and the mobility of the system. Furthermore, more extensive research is required to analyze and test the structural behavior and the connections of the proposed structural arrangements.

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Finally, I recite the words of Prophet Muhammad (PBUH): "Allah makes the way to Jannah easy for him who treads the path in search of knowledge".