Abstract

This research is an evaluation of the effectiveness of wind catchers as means of providing thermal comfort for modern residential buildings in the hot arid climates in the UAE. Though this research involves a residence in Abu Dhabi as a case study, it stresses that the results obtained can be used for other regions with similar climates and in most instances are largely applicable. A computer simulation tool, IES VE 2013, is used as a methodology to model spaces and different configurations that consist of the following parameters, are tested: floor to ceiling height of the space, area of the window opening, height of the wind tower, orientation of the wind tower, percentage opening of the window and the percentage opening of the wind tower opening. An automatic condition profile is imposed on the window and wind tower openings by the software so that they open and function only when these conditions are satisfied.

The study initially reviewed literature already existing on the integration of traditional sustainable techniques in the UAE. Further studies were done on how integral wind catchers were in traditional architecture to provide cooling for occupants in residences.

The simulations were carried out in two steps. As a first step, the case study building as it exists was subjected to a thermal simulation analysis. Results were obtained in terms of annual hours within the human thermal comfort range and Degree Discomfort Hours (DDH). The second step involved carrying out a series of simulations according to a test matrix, results obtained were analysed in comparison to the existing case. Of the configurations tested, the optimal configuration bore the following characteristics: Floor to Ceiling Height of 6m, wind tower height of 9m with North West orientation, window area of 3 $m^{2,}$ wind tower opening of 2 m^2, Percentage window opening of 100% and a percentage of wind tower opening 100%.

The optimal configuration when tested resulted in 47.1% decrease in degree discomfort hours and a 22.1% increase of hours annually in the thermal comfort range when compared

to the existing case. Furthermore, when the existing case was re-simulated with a cooling device switched on, it was estimated that the existing case consumes 39.5% more energy than the optimal configuration.

The study concludes by identifying guidelines for the implementation and use of wind towers in the modern age and with recommendations for future research.

الخلاصة

يقيم هذا البحث فعالية ملاقف الرياح كوسيلة لتوفير الراحة الحرارية للمباني السكنية الحديثة في مناطق المناخات الجافة والساخنة في دولة الإمارات العربية المتحدة. وعلى الرغم من أن دراسة الحالة التي يشملها هذا البحث تقتصر على مسكن معين في أبو ظبي، إلا أنه يؤكد على أن النتائج المحققة بالإمكان استخدامها في مناطق أخرى لها نفس المناخ وأنها قابلة للتطبيق إلى حد كبير. تم استخدام برنامج IES VE 2013 للمحاكاة الحاسوبية كمنهجية لتشكيل مساحات وتكوينات مختلفة تتألف من المعلمات التالية: ارتفاع السقف عن الأرض، ومساحة فتحة النافذة، وارتفاع برج الرياح، واتجاه برج الرياح، والنسبة المئوية لفتحة النافذة والنسبة المئوية لفتحة برج الرياح، وقد تم اختبارها جميعاً. كما يقوم البرنامج بفرض توصيف الشروط التلقائي على فتحات النافذة وبرج الرياح بحيث تفتح وتعمل فقط عند إستيفاء هذه الشروط.

في البداية استعرضت الدراسة البحوث الموجودة بالفعل على دمج التقنيات التقليدية المستدامة في دولة الإمارات. وقد أجريت دراسات أخرى حول كيفية دمج ملقف الرياح في العمارة التقليدية لتوفير التبريد للنزلاء في المساكن.

تم تنفيذ عمليات المحاكاة على مرحلتين، تضمنت الأولى إخضاع المبنى موضوع دراسة الحالة كما هو إلى تحليل المحاكاة الحرارية. تم الحصول على النتائج من حيث ساعات العمل السنوية ضمن نطاق الراحة الحرارية البشرية وساعات درجة الانزعاج. أما الثانية فانطوت على تنفيذ لسلسلة من عمليات المحاكاة وفقاً لمصفوفة الاختبار، وقد تم تحليل النتائج المتحصّل عليها بالمقارنة مع الحالة القائمة. وقد تبين من التكوينات التي تم اختبارها أن التكوين الأمثل يتمتع بالخصائص التالية: يرتفع السقف عن الأرض ٦ أمتار، بينما يبلغ ارتفاع البرج ٩ امتار ويواجه ناحية الشمال الغربي، أما النافذة فمساحتها ٣ أمتار مربعة ومساحة فتحة البرج تبلغ مترين مربعين، وتبلغ نسبة فتحة النافذة ونسبة فتحة برج الرياح معاً نسبة ١٠٠٪.

أسفر التكوين الأمثل عند اختباره عن انخفاض بنسبة ٤٧,1٪ في عدد ساعات درجة الانزعاج وزيادة بنسبة ١,٢٢٪ في الساعات السنوية في نطاق الراحة الحرارية بالمقارنة مع الحالة القائمة. وعند إعادة محاكاة الحالة القائمة بوجود جهاز التبريد في وضع التشغيل، قُدّر بأنها تستهلك كمية من الطاقة تفوق

التي يستهلكها التكوين الأمثل بنسبة ٥,٣٩٪.

وفي الخاتمة تحدد الدراسة مبادئ توجيهية لتنفيذ أبراج الرياح واستخدامها في العصر الحديث وتقدم توصيات للبحوث المستقبلية.

Dedication

To my unborn child, who will be born to a world and an environment more corrupt than that of the generation before, this environment bequeathed by my generation and those before mine, is his or her *damnosa hereditas*.

I hope and pray that my child will do the utmost to leave this environment a place better than when it was found.

To my maternal grandfather, who passed away whilst I was still writing this dissertation and whose funeral I couldn't be there for. The vivid memories of his care towards me continue to make me forget that he isn't around to read this; I know he would have been proud. If anyone benefits from these chapters, to him are part of the blessings.

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My sincere and strong prayer is that for as long as anyone benefits from these chapters, upon those mentioned above and their families, may Allah's choicest blessings be showered.