AN ARGUMENT AGAINST AIR CONDITIONING USE IN TROPICAL RESORTS

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Abstract

Conflicting and somewhat controversial views on using air-conditioning in tropical tourist resorts were revealed during a recent study tour of several countries in the Pacific region. Although conscious of detrimental implications for the environment, economics and even operational aspects of the use of mechanical devices to provide indoor comfort to visitors, many resort managers claimed market pressure has been the driving force behind the installation of air-conditioners within their facilities. This study follows an earlier survey of tourists visiting northern Australia, which demonstrated significant dissatisfaction with the indoor climate. The rationale for a year-round, fully controlled environment was found questionable when, in the hot and humid weather of the tropical summer, nearly half of the surveyed tourists did not perceive those conditions as justifying the use of air-conditioners. Responses collected through the visitor survey proposed that tourist resort developers and operators' understanding of tourists' needs in this respect was flawed. This difference in opinion has been confirmed in the current study, where managers were adamant as to the need for air-conditioning despite their units being capable of performing reasonably well without it. This paper presents the findings of the study and attempts to draw conclusions in regard to the perceptions and policies influencing design of tropical resorts.

Keywords

Air-conditioning, tropics, comfort, tourists, resorts

Introduction

Tourists visiting a tropical resort face problems specific to vacationing in the tropics. Outdoors, there is humidity and high temperatures not found in more temperate climates. The indoor environment, as offered to tourists, quite frequently contradicts their expectations (Bromberek, 1999). The problem appears to be attributed to resort design, which often seems incapable of responding adequately to the particulars of the location or climate.

The tropics are popularly misconstrued as having an "unbearably hot and humid for visitors" type of climate. Generally, this is not the case in the dry tropics, where relative humidity is low and large diurnal temperature swings offer nightly relief throughout the entire year. In the wet tropics, however, while humidity is elevated for most of the year, high temperatures tend to be a significant problem during only two or three summer months. For example, one computer simulation of indoor

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temperatures—in ordinary non-air conditioned buildings—compared to the comfort range as proposed by Szokolay (1990; compare Auliciems and Szokolay, 1997:46) suggested that in Cooktown, the northernmost township in Queensland, temperature would be too high for 6.2 per cent of the year, if only air moved at speeds of 1.0m/s or higher and just 1.9 per cent at air velocities exceeding 1.5m/s (Bromberek 1995). This equates to just a few hours per day during the hottest two or three months! Even then, however, tourists are inclined to stay outdoors and willingly expose themselves to those high ambient temperatures, humidity and solar radiation. Places, where tourists prefer to be during the day, for instance on the beach or in the rainforest, can display much higher levels of mean radiant temperature or humidity than other areas at the time. For this reason and more, it can be argued that, with respect to comfort, tourists should be considered a group of building users distinctively dissimilar to residents. Their perceptions of the climate seem to be influenced by their different attitudes.

Tourists, moving around the world, carry their specific expectations as to the anticipated local conditions. It seems that they travel in quest of different experiences and quite often are prepared to pay for them with some "discomfort allowance". Their expectations, influencing their preferences, differ from those of residents. The survey carried out by the author (Bromberek, 1999) indicated that conditions in most tropical areas would seldom be outside their "acceptable discomfort" scope. As it seems, most recreational activities occur in conditions when discomfort is perceived as agreeable and accepted (compare Baker, 1993:7-12). It could be, in fact, an integral part of pleasure and enjoyment associated with various leisure activities.

The problem is that this different perception of the tropics is not translated into a different indoor climate design standard. The current standards have been developed using thermal comfort research results, which reflect a relationship created by long-term physiological reactions to external conditions. They, in turn, have proven quite accurate in describing perceptions of local residents, exposed to given conditions for months at a time. Visitors differ from residents also in other aspects. Along with the dramatic rapidity of climate change (coming from a cold/moderate zone to the tropics is for them a matter of hours rather than days or weeks), there goes a specific behavioural pattern putting them in two different environments: one for the day and another during the night. Day-time activities, as it is usually the case, are spent in open-air spaces, with deliberate and willing exposure to otherwise intolerable conditions of high solar irradiation and high temperatures. It is only at night-time, when tourists retire to a shelter, that they seek conditions they are comfortable with.

Tourists' choices concerning their holiday destinations are considered and deliberate. One could say that they would not go to the tropics if they felt uncomfortable about the anticipated heat and high humidity. Many tourists choose to spend holidays there in search of the "tropical experience". While residents commit themselves to their home location and cannot easily leave (for various reasons) even though they might not have fully accepted the tropics, tourists are not compelled to stay there. They are able to come and go as they

please. Almost all constraints of regular life are also removed during holidays and tourists can actively participate in creating their own environment—in a broad sense of the word.

During a recent tour of several tropical locations in the Pacific (figures 1-9), a limited study of tourist resorts was undertaken with the aim of establishing the main characteristics of the response to the climate offered by those claiming to be "environmentally friendly". The study of indoor conditions, as reported in this paper, delivered collateral findings on the use of, and resort operators' attitudes towards, air-conditioning. The examined conditions were limited to a period, which was believed to be average for the year. The study further focussed on night-time temperatures and comparisons with corresponding thermal neutralities and Humidex indices. The night-time temperatures represent the environment as that being actually used by the tourists and both thermal neutrality and Humidex index (see below for definitions) accurately describe thermal stress accounting for the approval or otherwise of the conditions experienced. While this approach clearly had its limitations, it complemented the earlier survey mentioned above and further questioned the current position of air-conditioning in tourist resorts. Most units were found performing reasonably well without air-conditioning, which dented the established beliefs and delivered an argument against its use on a year-round basis. Changing this could help alleviate detrimental implications for the environment, economics and even operational aspects of using mechanical devices to provide indoor comfort to visitors.

Figure 1: Repairs on a traditional Fijian roof of the dining hall, Vanua Levu resort.

Figure 2: Bungalow at a former palm plantation site, Naigani resort.

Figure 3: Interiors at Rarotonga 1 resort have unfinished plywood walls and no air-conditioning.

Figure 4: Garden Bungalows at Rarotonga 2 resort.

Figure 5: Simple owner-built structures of Aitutaki resort.

Figure 6: French Polynesia is renown for its traditional over-the-water bungalows, Moorea resort.

Figure 7: Reef-protected lagoon location is the major asset of Bora Bora resort.bungalows.

Figure 8: Wind generator and solar panels are the only sources of power at Tulúm resort.

Figure 9: *Tentalapas* of Rio Indio resort are built directly on the beach.

Environmental Comfort in the Tropics

Nearly every person has different expectations and different perceptions of conditions in the environment. Researchers and designers search for a combination of the perceived conditions found comfortable if not by all then at least by the majority of building users. Let us describe a full set of favourable conditions as the 'environmental comfort'. The basic literature of the subject, for example Fanger (1970), Koenigsberger et al. (1973) or ASHRAE (1985), use for this purpose a concept of thermal comfort. Thermal comfort is believed to be a dominant problem in tropical climates (Koenigsberger et al. 1973:41). It is, however, only a subset of the environmental comfort. For instance, Forwood (1980:150) indicated that the basis for environmental comfort definition could be derived from a well defined concept of thermal comfort—usually understood as a condition at which there is no sensation of thermal discomfort from cold, heat, excessive skin wetness or dryness, air stuffiness, or air moving at high speeds. Moreover, according to Macpherson (1980:13)

[a] "thermal environment may be said to be 'comfortable' when the physiological strain resulting from the imposed thermal stress either does not impinge on consciousness, or if any sensation of heat or cold is evoked, this sensation is not unpleasant."

Macpherson elaborates further that whether or not any given situation is accepted as thermally comfortable depends in part on the environment, and in part on a judgement by the individual exposed to the environment (id.). Also in ASHRAE's (1985) description, human thermal comfort is "a state of mind, subjectively assessing current physical conditions". This is a very important statement. It allows for a very special role in thermal comfort to be played by psychological factors, such as expectations and preparedness (Szokolay, 1985:276–280). These factors, generally expressed as attitude, could be the most significant for comfort perception among tourists.

The current understanding of thermal comfort follows a concept of "universal uniformity" of human comfort, present in research on physiology since the 19th century. The latter concept was based on an objectively rational observation that the human body maintains constant internal temperature of about 37.0°C independently of external conditions. To achieve such thermal balance, the body employs complex thermoregulatory mechanisms. They work well and ensure comfort in quite a broad range of conditions—much broader, in fact, than we tend to assume. For instance, Humphreys' and Auliciems' reviews of thermal data from around the world indicated a positive correlation of preferred indoor temperatures and outdoor climatic conditions. They have introduced a concept of thermal neutrality—a temperature at which a subject does not feel either cool or warm. It can, to some extent, represent thermal comfort conditions. Humphreys found a statistically meaningful relationship between the thermal neutrality T_n and mean monthly temperature of ambient air (Humphreys, 1978:4). Data, on which his linear regression was based, were later revised and supplemented by Auliciems, which led to a subsequent revision of Humphreys' equation (Auliciems, 1981:76–80). A similar result was obtained on the Indian subcontinent by Nicol (1995:3-7):

$T_n = 17.0 + 0.38\ T_o$ (1)

where T_o represents outdoor monthly mean temperature. The range of application is from 10° to 30°C.

Even the Nicol's equation, which was based on data from predominantly warm climates (the Humphreys' and Auliciems' equations were based on data from most climatic zones around the world, including the sub-polar), does not seem appropriate for use in predictions of comfort among tropical tourists. The reason is that their results are derived from research on residents—they do not account for acclimatisation or other differentiating factors. The equations do not take activity levels into account and assumptions concerning only behavioural adjustments are inadequate. Furthermore, an important role played by psychological factors, such as climatic adaptation based on one's expectations (Auliciems, 1983; de Dear, 1994), has not been accounted for. Most importantly, the equations require monthly mean temperature as input while the average length of tourist visits to the tropics is no more than a few days. In tourist resorts, this psychological aspect of comfort perception should be emphasised much beyond its role in residential buildings. The survey of the preferences of tourists visiting the tropics in this respect have been investigated on their departure from the region was carried out in the summer of 1994 in Cairns, Far North Queensland (Bromberek, 1999). It confirmed the author's belief that a different (psychological) position of tourists in the tropics made most of them see conditions there acceptable, and the use of air-conditioners in their accommodation not required. It follows that offering indoor conditions, which were further improved by the means of passive climate control would make conditions acceptable to an even larger number of guests. Providing indoor conditions that are not much worse than outdoors could be sufficient for the vast majority of them.

One can look at the problem from a completely different perspective. We can compare tourists changing climatic zone with people staying at home when the weather changes rapidly and the conditions persist for a number of days. An interesting thermal stress indicator, the Humidex was proposed in 1979 by Masterton and Richardson (Lewis, 1993:541ff.) to combine effects of temperature and humidity during the so called "heat waves" in Canada (Table 1). A heat wave is defined by Canada's Atmospheric Environment Service as a period of three or more days with a maximum temperature greater than or equal to 29.5°C and a mean temperature of at least 24°C (Lewis, 1993:545).

Range of Humidex values	Degree of comfort/discomfort
20–29	comfortable
30–39	varying degrees of discomfort
40–45	almost everyone uncomfortable
46 or higher	many types of activities must be restricted

Table 1: Human response to a range of Humidex values

Source: P.J. Lewis (1993)

After a high correlation has been found between mean dry bulb temperature (DBT) and mean Humidex, the regression equation was suggested to base the indicator on temperature only (id.):

$$Humidex_{mean} = 1.13\ DBT_{mean} + 2.91 \quad (2)$$

Masterton and Richardson suggested that Humidex gives satisfactory indication of the degree of human discomfort likely to be encountered in given conditions. There is some merit in applying Humidex, or other similar index, to measure thermal stress in tourists. For a visitor to the tropics, local conditions are a sudden increase in temperature and humidity—exactly the same way as a heat wave at home would have been. This is not to imply that Humidex allows for prediction of heat stress from temperature means alone. Nevertheless, it displays opportunities unlocked by this method. It will be used below, together with the Nicol's comfort equation (1), to describe and assess indoor environment of the studied resorts.

Indoor Conditions in the Visited Resorts

The adopted methodology included criteria-based selection of resorts and timing of visits, selection of what was measured and how it was done as well as comparisons between the resorts drawn from visual surveys and interviewing resort managerial staff. Fifteen tropical resorts in four tropical countries were visited between 20 November and 16 December 2005. The period was a transitional "between the seasons" time, when temperatures usually are close to annual averages (Table 2). In fact, in all but one location annual minima were lower than the minimum observed temperatures and annual maxima were higher only in Mexican locations. The timing of the visits corresponded with "early summer" in the southern hemisphere and "early winter" in the northern. Precipitation is the main indicator of the seasonal change in the tropics even if frequency and intensity of the rainfall is more often determined by the specifics of the location, for instance its topography (compare Baker, 1987). Precipitation directly influences relative humidity (RH) but readings of RH taken during the study tour were consistently very high although significant rainfall was noted only in some Fiji and Cook Islands locations.

The resorts studied had been selected because of their claims to the environmental friendliness. Other criteria, on which the selection was based, included factors such as accessibility and representativeness (established by studying web profiles of approximately 350 resorts in the region). Resort locations were a fairly typical selection of tourist destinations in the tropics, with all but one resort built directly on the beach. The claims were investigated, various design features were photographed and/or described, operational data were collected, managing staff were interviewed and air temperature readings were taken, both inside and outside the allocated unit, continuously over 24-hour periods together with relative humidity readings indoors. Four of the visited resorts were found to be no different from other resorts in the area in terms of their energy efficiency or broadly termed relationships with the environment, hence to have no basis for the eco-resort status. Subsequently, they were discarded from the sample.

A digital thermometer/hygrometer with memory was used in assessment of thermal conditions

found during the visits. The use of the device's memory allowed recording the highest and the lowest temperatures as well as the highest and the lowest relative humidity during the diurnal cycle of the visit. The indoor temperature and RH readings were taken at the bedside at bed mattress height (approximately 0.5m above the floor). If there was air-conditioning and/or fan in the unit, they remained switched off during the entire measurement period. All windows fitted with flyscreens, on the other hand, remained open during the night. External temperatures were measured directly outside the allocated unit. Attempts were made to find a spot shaded during the entire day to exclude effects of direct insolation. Nevertheless, wall mass was poorly shaded (under 10% of perimeter wall area) in the majority of cases. The temperature readings are presented in Table 2 (RH readings were over 95%, at least at some point in time during the night, in all locations).

Resort location	Air-cond availability	Minimum temperature [degC] Average[a]	Inside	Outside	Difference	Maximum temperature [degC] Average[a]	Inside	Outside	Difference	Humidex index[b]	Thermal neutrality[c]
Vanua Levu, Fiji	Yes	21.6[1]	**26.4**	26.1	**+0.3**	27.9[1]	**29.1**	31.1	**−2.0**	*34.3*	26.4
Naigani, Fiji	No	22.4[2]	**25.9**	23.5	**+2.4**	29.0[2]	**34.9**	33.0	**+1.9**	*37.3*	26.9
Rarotonga 1, Cook Islands	No	21.9[3]	**25.9**	25.6	**+0.3**	26.3[3]	**30.0**	30.9	**−0.9**	*34.5*	26.2
Rarotonga 2, Cook Islands	Yes	21.9[3]	**25.9**	23.9	**+2.0**	26.3[3]	**29.4**	29.6	**−0.2**	*34.2*	26.2
Aitutaki, Cook Islands	No	22.1[4]	**27.4**	26.9	**+0.5**	28.8[4]	**34.5**	32.6	**+1.9**	*37.9*	26.8
Moorea, French Polynesia	Yes	21.0[5]	**27.4**	26.1	**+1.3**	30.7[5]	**32.0**	32.3	**−0.3**	*36.5*	26.9
Bora Bora, French Polynesia	Yes	23.4[6]	**28.9**	27.4	**+1.5**	29.0[6]	**30.9**	33.6	**−2.7**	*36.7*	27.0
Tulúm, Mexico	No	20.9[7]	**21.3**	18.9	**+2.4**	30.9[7]	**27.6**	28.0	**−0.4**	*30.5*	26.0
Bahía Permejo, Mexico	No	21.9[8]	**24.6**	22.9	**+1.7**	30.5[8]	**27.4**	26.4	**+1.0**	*32.3*	25.9
Rio Indio, Mexico	No	21.9[8]	**24.6**	24.3	**+0.3**	30.5[8]	**27.4**	26.6	**+0.8**	*32.3*	25.9
Chichén Itzá, Mexico	Yes	19.3[9]	**26.0**	23.9	**+2.1**	32.5[9]	**30.1**	29.9	**+0.2**	*34.6*	25.6
Average for 11 resorts		21.7	**25.8**	24.5	**+1.3**	29.3	**30.3**	30.4	**−0.1**	*34.6*	26.4

Table 2: Comparison of climatic annual averages with temperatures indoors and outdoors, corresponding Humidex indices and comfort ranges in the studied locations.

[a] Annual average minimum/maximum temperature at a meteorological station nearest to the resort: 1-Savusavu, 2-Nausori, 3-Avarua, 4-Ootu, 5-Papeete, 6-Motu Mute, 7-Tulúm, 8-Chetumal, 9-Dzitas

[b] Humidex index calculated for the observed indoor air temperatures

[c] Determined with the Nicol's equation; result in this column ±2deg gives 80 percentile acceptability (compare Auliciems and Szokolay, 1997:46), compare it with the observed night-time (minimum) air temperatures indoors

A half of the visited resorts had mechanical air-conditioning (AC) in guest accommodation offered as an option. Despite their environmental claims, managers in nearly all resorts were willing to provide air-conditioners as they felt "compelled by their markets" to do so. Furthermore, in all resorts that offered AC, room service was instructed to ensure that the air-conditioner was switched on. All the managers admitted in their interviews that the cost of providing AC was very high. Nevertheless, AC has not been seen as a factor impacting on the environment. The 'eco-resort' status was seen achievable by controlling tourist impacts, using natural building materials or blending their resorts, as a business endeavour, with the local community. Impacts from resort's operations, including noise and pollution generated by a power plant, have seldom been perceived as part of the "eco-friendly package". Even less so were the environmental costs of running supplies, for instance fuel. It is worth to note that the majority of fuel-free power generators, due to their reliance on unpredictable availability of sun, wind or water, are usually supported by back-up diesel generators even in the eco-friendly resorts (they have been used in all the visited resorts).

Discussion of Main Findings

Not a single resort amongst the visited was designed to utilise passive means of climate control. Features coming from vernacular architecture, which were replicated in their designs, often seemed superficial and dishonest. Such was a thatch covering metal decking on the roof to give it a traditional hut appearance or a roof monitor—blocked to seal the interior for effective air-conditioning. And yet, the indoor climate was in nearly all instances remarkably comfortable. Minimum (i.e. night-time) indoor temperatures recorded were always higher than the corresponding temperatures outdoors. This effect of unshaded building mass was most evident in heavy-weight structures of Rarotonga 2, Tulúm, Bahía Permejo and Chichén Itzá resorts. Even these higher indoor temperatures were within the comfort range determined by the thermal neutrality equation (1). In the only resort where night-time temperature was outside the range, it was actually lower than the ones called for by the equation (Table 2).

The author's own perceptions were in line with predictions arrived at with the Humidex index. Mild discomfort was felt in conditions resulting in Humidex values of 36.5 or more (three resorts out of the eleven surveyed). In all the resorts some degree of discomfort was predicted with the Humidex index; average score of 34.6 indicates that the discomfort would only be mild for most tourists and, allowing for their attitudes, could be acceptable to them during a short-term visit. However, the perceptions have been based on conditions achieved with no air-conditioning or fan working in the unit. Cross ventilation was not always possible, either. It is easy to imagine that the conditions would be greatly improved if only a slight air movement was induced. Most resorts relied on cross ventilation, cathedral ceilings and, in a few instances, (partial) shading to create comfortable indoor conditions. This did not seem a deliberate part of some "grand plan" to utilise passive design features. Instead, it was more like an accidental result of pursuing a romantic image that some of these resorts wished to invoke by reference to the vernacular. "Tourists coming to my resort

come here for a dream and I'm selling them that dream" as one of the resort owners put it.

More important than comfort or impact on the environment appears what the customer is prepared to pay for. Some of the visited resort designs used vocabulary of the vernacular without any deeper understanding of the role that certain features played in overall building performance. Modern adaptations of elements, such as roof monitors, thick insulation in the roof, effective cross-ventilation or high ceilings, have been treated as form-building rather than anything else. The traditional elements have been copied because they were fashionable. Sometimes they have been introduced by the local builders, for whom they were part of the local building tradition, but the reasons behind their use have not been accepted by the resort owners or developers. Reducing these elements, tried and tested over centuries, to nothing more than ornaments created a situation where such features do not contribute to improvement of indoor conditions. And yet, many of the visited buildings cope well with the tropical climate in its night-time part.

Lack of understanding of comfort perception in the tropical climates was also evident. When one of the managers agreed to a small experiment involving raising a temperature in his air-conditioned office by three degrees (to a level suggested by the Nicol's equation), he was genuinely surprised how cool it still felt after only a brief walk outside. His experience, on which he was basing his decisions about temperature setting for AC in guest units, was derived from working in the office all day long. Findings from the earlier research suggested that the passive climate control should involve specific requirements of the users. It should also exploit the identified differences between the tourists, who are only temporary visitors to the tropics, and the residents. Many traditionally indoor activities can also be moved outdoors, this way reducing possible discomfort. Results from the 1994 survey indirectly indicated that most tourists are satisfied when the indoor climate does not differ significantly from the outdoor conditions. Such an outcome is achievable without the use of air-conditioning. One might even think that a combined effect of all passive means, which can be used, would ensure conditions that are actually better than out in the open (compare Tombazis, 1993). Improvements can be relatively easily accomplished in areas of mean radiant temperature, air movement, light and sound levels. Before mechanical control systems had even been invented, environmental comfort was achieved by passive means supported by adjustment of behaviour to particular conditions. There are still in place a number of vernacular solutions working in tropical regions around the world with remarkable efficiency. Without doubt, at least some of these solutions can be adopted in tourist resort designs, emphasising their regionality and lowering their energy demand at the same time.

Conclusion

The study of the several different resorts in various tropical locations investigated a selection of designs, randomised from the "environmental response by design" point of view. Notwithstanding its relevance, it appears that reaching to the vocabulary of the vernacular does not mean that developers fully understand the role of all the features or benefits

of using them in their modern adaptations. Certain features, having an obvious and large impact on the indoor environment, such as roof monitors, thick insulation in the roof, effective cross-ventilation or high ceilings, were often introduced by incident. Some of these passive climate controls and workable environmental solutions have been subsequently removed from the comfort equation by sealing the indoor environment in order to have effective air-conditioning. The end result was a haphazard mixture of passive design features playing their original role unintentionally or reduced to mere ornaments. The study results indicate that many of these "incidental creations" cope well with the tropical climate in its night-time part.

The study did not find justification for air-conditioning in tropical resorts laying claim to "environmental friendliness". The indoor conditions during the night i.e. the time when units are actually used by tourists, corresponding with average tropical weather outside, seldom are uncomfortable enough to require a mechanical device to modify them. Running air-conditioning in a typical resort location could be expensive, both economically and also in the environmental sense of the word, while numerous examples from vernacular architecture have delivered sufficient proof that comfort in the tropics is achievable with passive measures only. Also, the way most developers and designers see comfort in the tropics, generally does not correspond with the real visitor requirements. The design recommendations should offer solutions focussed on night conditions to suit resort character. Both the current and earlier research by the author indicate that human comfort in tourists requires different metrics. These new guidelines should embrace specificity of sudden short-term change of conditions, behavioural differences from residents and different attitudes to make them relevant in resort design.

The current study delivered further proof that indoor conditions in the tropics can fall well within the comfort range—without mechanical support. However, replacing mechanical air-conditioning with good climate–responsive design is for architectural professionals also an ethical issue. It is architects' moral obligation "[to] build the shelter in such a way as to bring out the best of the natural possibilities" as brothers Olgyay stated as early as in 1957. Removing air-conditioning from tropical resorts is not only possible. It could also be better for the environment and more economical for the operators. It could also be more satisfying for the tourists.

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