

# Linking bioclimatic theory and environmental performance in its climatic and cultural context – an analysis into the tropical highrises of Ken Yeang

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**ABSTRACT:** This paper presents the outcome of an environmental performance analysis and theoretical study into the bioclimatic highrises of Malaysian architect Ken Yeang – with a focus on the tropical climate. By focusing on case studies representing the three main phases of Yeang's work, the impact of features such as core placement, sky courts, balconies, shading system and vegetation system are evaluated in terms of cooling and total energy use under the Malaysian climate. The climatic performances of the bioclimatic high-rise envelopes are then tested through comparisons with generic highrise forms. The study highlights the link between bioclimatic theories and climatic 'performances' and any conflicts between them. A paradox between theories based on critical regionalism and bioclimatic intentions are also described. Yeang's designs are then evaluated in terms of overall forms rather than separate components. The study then focuses on the debate on critical regionalism and sustainable design, the balance of modernization and traditional values within the context of developing cities, and the significance of bioclimatic and critical regionalist theories in forming the basis of a sustainable architecture appropriate to its cultural and climatic context.

**Keywords:** bioclimatic performance, tropical highrise, energy simulation, critical regionalism, sustainable theory

## 1. INTRODUCTION

There is, at present, a rising interest in examining the theoretical aspects of sustainable architecture – when practiced and applied within a particular climatic and cultural context. There is a need to integrate both fields, of the 'art' and 'science' of sustainable architecture in developing a theoretical framework that can govern design decision-making. As Hawkes (1997)[1] points out: '*Decisions about technique in architecture are primarily cultural and aesthetic matters and it is impossible to base these complex choices solely upon objective technical considerations*'. In his essay on green design, Brennan (1997)[2] observes: '*Any inherent meaning a green building may have is dependent entirely on its physical content and performance and such meaning is difficult to express visually*'. Burckhardt (1998) [3] makes a useful observation:

*'Ecology's most important problem is that it is invisible. You cannot produce the visual sensation of harmony simply by being ecological anymore than the reverse... The same is the problem with architecture - you cannot see an ecological building..'*

Generally, there is a lack of rigorous studies on the implications of more intuitive approaches by architects towards sustainable design in general, and bioclimatic design, in particular. The ability of architects to solve design problems, according to

Alexander (1964) [4], is linked to an ability to understand '*...the pattern of the problem (which) is comprised of all the interactions between one requirements and another*'. Lawson (1990) [5] also observed, in his study on design methods: '*It is the very interconnectedness of all these factors which is the essence of the design problems rather than the isolated factors themselves...*'

The aim of analysing Ken Yeang's theories and designs is to undertake a study and evaluation of a more 'integrated' architectural approach to climate-interactive design. Yeang's theories and designs represent an opportunity to highlight the interaction between architectural ideas and their implications in terms of environmental performance under its particular climatic and cultural context. By analyzing the positive and negative outcomes of such aspects, the architectural parameters/ constraints and its implications in terms of environmental strategies can be evaluated. It gives the opportunity to study the contextual framework of implementing bioclimatic principles and to relay the ideas which underlie passive design and drive the processes of innovation.

Powell (1999) [6] observes on the need to link 'theory' and 'performance': '*Yeang is often criticized for the apparent disparity between his theoretical writings and his buildings; it is difficult to juxtapose the theory alongside the built work....*' Rattenbury (2000) [7] suggests a more detailed study is necessary: '*...It would have been extremely interesting to see a few*

*examples in detail, with successes and failings and overall progression in Yeang's thinking set out'.*

Malaysian architect Ken Yeang is well-known for the development of theories on the 'bioclimatic skyscraper' applied in a multitude of projects in Malaysia and throughout the world. By focusing on 3 case studies in Malaysian i.e. the Plaza IBM (1984-1987), the Mesiniaga (1989-1992) and the Menara UMNO (1996-1998) which represent the three main phases of his work (1970s to the 1990s), this study evaluates climatic and energy performance of key 'bioclimatic features' and the overall 'bioclimatic' forms under its climatic context. The aim is to highlight the links or conflicts, if any, between 'theory' and 'performance'. The IES-VE simulation program was used to test the sensitivity to features such as core placement, skycourts, balconies, shading and vegetation to cooling and total energy use under the Malaysian climate. The overall envelope performances of the high-rises are then tested through a constrained optimisation to evaluate their performances under the competing considerations of solar heat gain and daylight performance in the tropics. A post-occupancy study was also undertaken (Jahnkassim, 2004)[8] to validate the simulation results – but the discussion is beyond the scope of this paper. The importance between the link, conflicts or relationship of Yeang's theories – including notions of the 'critical' vernacular linked to critical regionalism and the performances of his bioclimatic designs - is also discussed.

## 2. METHODOLOGY

The theories of the 'bioclimatic skyscraper' had evolved from the environmental filter ideas in the 1970s to theories of bioclimatic/ecological design in the late 1990s. Powell (1999)[6] for example, identifies 3 major phases within the gradual development of the theories. In his 'Rethinking the Skyscraper' (1999) [6] he describes these as:

- the '**climatic**' phase - based on intuitive climatic principles and focused on the idea of the environmental filter;
- the '**regionalist**' phase- based on a search for a distinctive regional language within the tropical Asian context;
- the '**bioclimatic/ecological**' phase - directed towards a more 'global' context and focused on the environmental agenda.

In the following analyses, three highrises are selected which represent an amalgamation of Yeang's ideas during the evolving periods. They are tested in terms of separate features and overall forms. The performances are then linked with the ideas and intentions underlying their architectural forms. The IES-VE (Integrated Environmental Solutions- Virtual Environment) suite of programmes integrates the thermal simulation program APACHE with various other sub-programs. The philosophy behind the APACHE program is to provide an integrated suit of programs linked by a common data

model. The data required for APACHE is derived from a 3D data model, which is created by a model creation tool called MODEL-IT. It provides the capability of creating a 3D geometry model quickly and without the need for a CAD system.

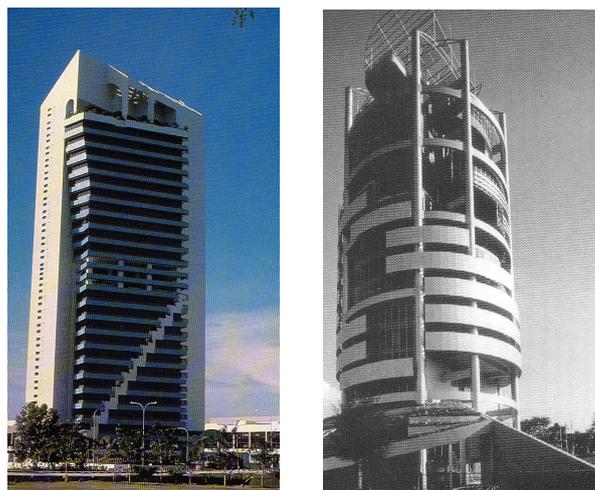
Basically the subprograms used in this analysis is the integrated thermal simulation program APACHE, the building modelling program MODEL-IT and the shadow analysis program SUNCAST. These are used to analyse the impact of design features and overall envelope in terms of the cooling and envelope energy performances under the Malaysian climate. In order to assess the energy impact of the designs, the bioclimatic forms and features are compared with 'generic' options for the purpose of benchmarking. These represent the basic shape or form of the highrises on which the features are applied or the optimisation analysis are performed.

The 'bioclimatic' option refers to the highrise model as designed by Yeang. The 'generic' forms are based on the primary shapes underlying the designs. For Plaza IBM, a rectangular highrise is its 'generic' counterpart; for the Mesiniaga, a cylindrical tower; and the UMNO, a rectangular tower. In past simulation studies, these options are sometimes called 'base-case' or 'typical' models (Rao, K.R., 1988) [9].

## 3. STUDIES ON BIOCLIMATIC FEATURES

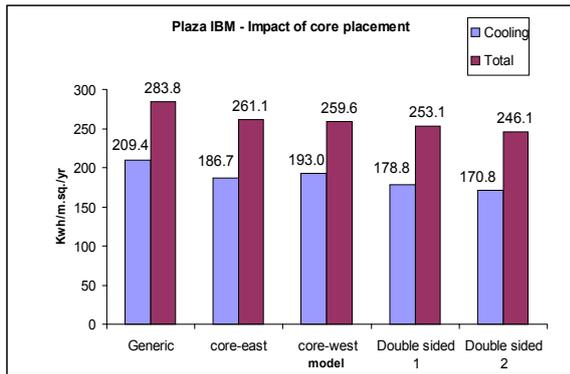
### 3.1 The impact of core-positioning - Plaza IBM

Placing cores on the periphery decrease the amount of glazed openings – thus limiting solar gain. Figures 2 and 3 show a resultant impact of about 8 - 10% in terms of reductions in total and cooling energy use.



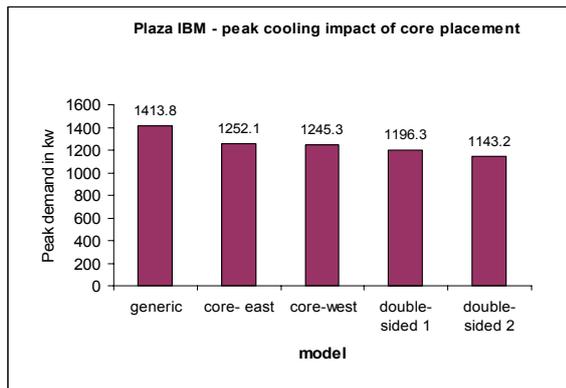
**Figure 1:** Plaza IBM (left) and Menara Mesiniaga (right)

The peripheral service cores tested are single sided East, West and two double- sided core positions.



**Figure 2:** Plaza IBM – impact of core placement options to energy consumption

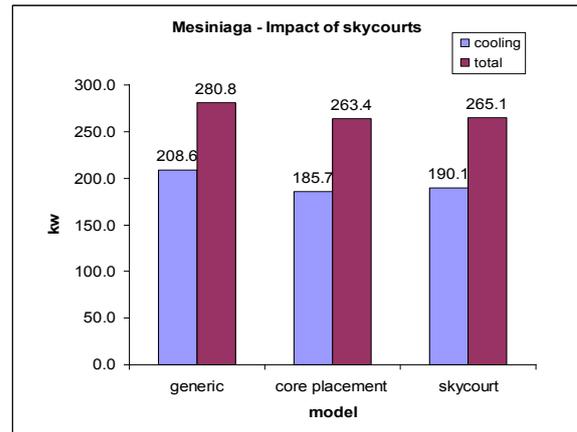
This provides a ‘buffer space’ on the ‘hot sides’ of the tower. The extent of reduction is, however, dependent on orientation factors and the amount of glazed facades. In all cases, the impact of double-core positioning is the most significant, outperforming the impact of single-sided options.



**Figure 3:** Plaza IBM – impact of core placement options to peak cooling load demand

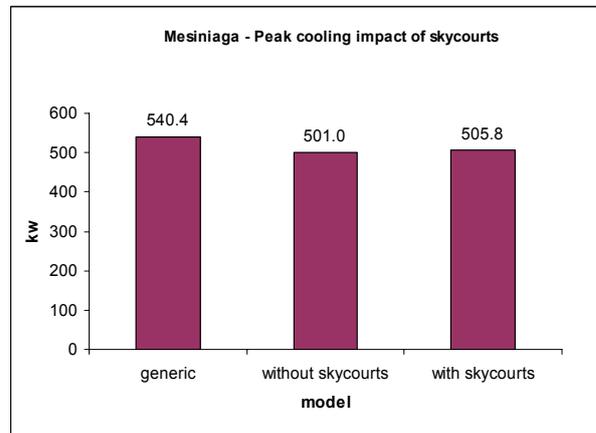
### 3.2 Impact of skycourts - Menara Mesiniaga

The skycourts are modelled as ‘incisions’ into the basic cylindrical model and are located on all floors except the 1<sup>st</sup>, 2<sup>nd</sup>, 11<sup>th</sup> and 12<sup>th</sup> floors.



**Figure 4:** Mesiniaga – Cooling and total energy impact of skycourts (bioclimatic)

Although skycourts may play a role as ‘thermal buffer’ that reduce the impact of solar radiation and glare entering from the western facades, its benefits are seen to be offset by an increase in cooling loads i.e. in terms of conduction gains (Fig. 4 and 5). The incisions made by the skycourts compromise the otherwise efficient form of the basic cylindrical tower. In the tropics where heat gain travels unidirectionally into an air-conditioned building throughout the day – increasing the surface-to-volume ratio with a significant impact on cooling loads. Because the skycourts ‘spiral’ from the south to the north rather than inserted in ideal positions on the west – not all areas are effectively shaded.

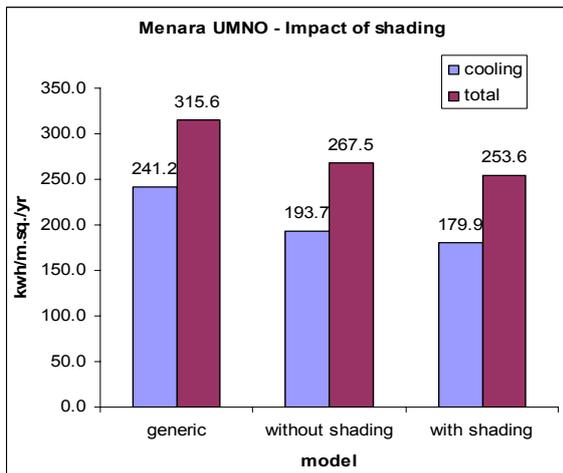


**Figure 5:** Mesiniaga – Impact of skycourts (peak load)



**Figure 6:** Menara UMNO (Penang) – the western façade showing the shading system

The ‘Shading’ strategy outperforms ‘core-placement’ strategy as this directly reduces the amount of solar radiation impinging on the building envelope. This supports the findings from previous studies - ‘fenestration design’ is seen to be the most significant factor affecting energy use in air-conditioned high-rise buildings in the equatorial tropics (Tham, 1987) [10]. The results also show that if the shading is correctly configured to cut off direct radiation at critical times of the day, the impact can be significant.



**Figure 7:** ‘Overall’ performances of the bioclimatic envelopes

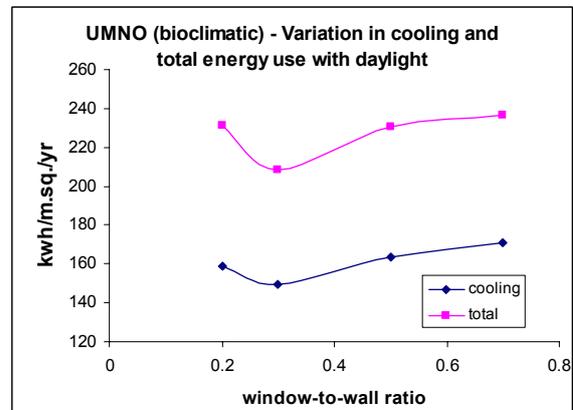
The results – as summarised in the Figure 7 - confirm that the highest savings in terms of energy performance are mainly attributed to features that have the highest solar control under the tropical climate

### 3.3 The Bioclimatic Envelope

By focusing on the variation of window area with daylight savings, the analysis isolates the impact of the overall forms i.e. the ‘bioclimatic’ envelopes in terms of climate. It gives an indication of the effectiveness of the ‘bioclimatic’ envelopes in filtering the two primary tropical climatic parameters of daylight and heat gain. A comparison is then made between the ‘generic’ and ‘bioclimatic’ (with and without daylighting) optimised performances

In the case of IBM and MNNO, the ‘bioclimatic’ options outperformed their counterpart ‘generic’ options. These have been optimised with regards to daylight. The highest savings by the optimisation analysis with daylight is achieved by the Plaza IBM model – which have windows orientated to north-south diffuse skies of the tropics. (However due to the presence of glazed openings on the east and west of the IBM, these have some negative impact in terms of some gains in cooling loads and overall energy use). This impact is however, minimal if compared to the case of Mesiniaga – where the ‘generic’ (optimised) option completely supersedes the bioclimatic option. The results for the Mesiniaga indicate some conflict between the overall forms of the ‘bioclimatic’ envelope and its effectiveness in terms of climatic performance under the tropics.

The results give an overall picture of the overall performances of the bioclimatic envelopes under the tropical climate. In the case of Plaza IBM and Menara UMNO, the optimised ‘bioclimatic’ options outperform their counterpart window-less wall options – implying that the envelope performances of the ‘bioclimatic’ forms – represented by the IBM and UMNO - can be reduced to levels below those of the windowless wall options (see example of optimisation in figure 8). However in the case of the Mesiniaga, the windowless option still outperforms its counterpart ‘bioclimatic’ (optimised) option – indicating that the ‘bioclimatic’ form of the Mesiniaga is significantly less efficient in its climatic performance i.e. in terms of balancing the positive and negative impacts of daylight and heat gain.



**Figure 8:** UMNO – Example of optimisation process which indicate the window area where the balance between the positive impact of daylight and negative impact of heat gain is achieved

Through this process, the performances of the 'bioclimatic envelopes' are thus evaluated not only in terms of the impact of their separate 'features' or components, but overall forms. More importantly, to link their climatic performances to more fundamental ideas associated within their underlying theories. The aim is to analyse the skyscrapers in terms of the overall forms - and to link them to the emphasis within Yeang's theories and writings during their respective periods.

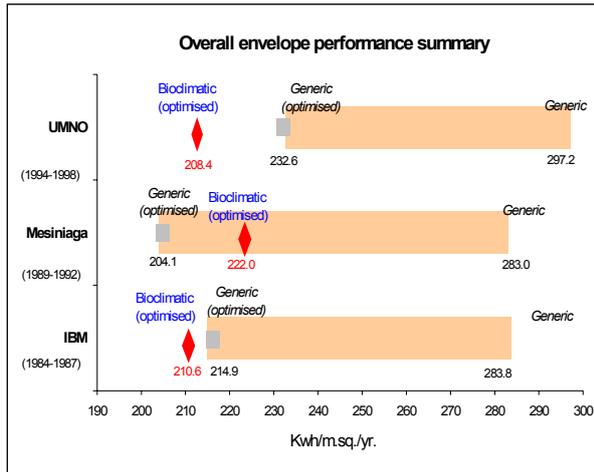


Figure 9: Overall envelope performances

The results in figure 9 illustrate the overall efficiency of the 'bioclimatic highrise envelopes' in terms of filtering and balancing the positive and negative impacts under the Malaysian climate. The net impact is a function of two of the most significant parameters under the tropics – the extent of its positive impact in terms of maximising the use of daylight and its negative impact in terms of heat gain. This, in turn, is a function of building configuration and shape or form – which determines the extent of usable daylight and surface area exposed to the external climate.

### 3.3.1 The Plaza IBM (1984 - 1987)

The Plaza IBM's optimised 'bioclimatic' envelope outperforms its 'generic' counterpart – showing its effectiveness in terms of overall form and configuration in balancing the impact of solar heat gain and daylight. The overall performance is affected by its form and envelope design. Results of the post-occupancy studies also confirm the benefits of the strategy of limiting heat gain on the east and west sides of the towers. In general, the IBM envelope represents a bioclimatic envelope that successfully performs in terms of interactions with the tropical climate i.e. of filtering daylight and heat gain.

The results reinforce that under the tropics, the ideal 'bioclimatic' form should have no glazing or openings on the eastern and western facades while having optimal shading on openings facing north and south. These openings should seek to balance between the maximisation of daylight while minimising heat gain and discomfort associated with

any incidence of glare in the tropics. In the case of Plaza IBM, if the bioclimatic features are correctly configured, the results show that it can outperform its generic counterpart. The performance of IBM can be linked to Yeang's ideas during this period – which emphasised the idea of the 'environmental filter' and related specifically to the tropical context. The aim was to create 'an archetype suitable for the tropical climate'. In contrast, the overall performance of Mesiniaga's 'bioclimatic' envelope was not able to outperform that of its 'generic' counterpart. Its overall envelope performance is mainly affected by the spiralling incisions made into its basic form (compared to a more efficient homogenous cylindrical form). The cooling impact of the 'spiralling skycourts' was unable to offset the consequent conduction gains due to an increase in its surface-to-volume ratio.

The results emphasise that for an air-conditioned building in the tropics, the compactness of form determines overall exposure to heat gains while allowing a certain level of perimeter areas to be lit by usable daylight. A more fragmented form will increase surface-area exposed to climate - thereby increasing heat gain. However at the same time, the extent of usable daylight i.e. within perimeter areas will also increase. Hence the net effect - in terms of overall performance of the bioclimatic envelope or form - is thus representative of the interaction between the control of heat gain and provision of usable daylight under this climate.

It has been discussed that Mesiniaga was designed during the primarily tropical 'regionalist' phase of Yeang's theories and designs. His regionalist intentions are clearly encapsulated in his seminal publications during this period - The Tropical Verandah City (1986)[11] and Tropical Urban Regionalism (1987) [12].

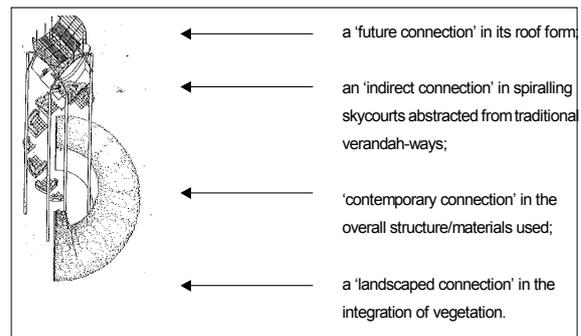


Figure 10: 'Tropical Urban regionalist' principles in Mesiniaga

Yeang's critical regionalist ideas were driven by his 'image' of a tropical city – particularly his vision towards developing a unique identity for Kuala Lumpur. Basically his ideas for a tropical city is based on the concept of connecting gardens and boulevards - through a system of 'verandah-ways' – into the fabric of the city. The emphasis on skycourts in theory and design is thus derived from the idea of 'verandahways' as 'a continuation of the landscaped boulevards from the ground level to the sky'.

Powell (1999)[6] has highlighted how the criticisms received by Yeang during an earlier

regional seminar in South-East Asia spurred him towards a more assertive language. Singaporean architect Tay Kheng Soon comments on the Plaza IBM:

*The Corbusian image, the planar aesthetic, keeps creeping in, even though we profess to want to break the planes and soften the edge of the building. Before we can have a soft-edged building, we have to develop a soft-edged aesthetic by which to convey the idea. Instead we continue using hard-edged aesthetic and trying to get it to carry the soft-edged message we want to convey.*

Hence in contrast to the Yeang's earlier designs, including the IBM, Mesiniaga's form consists of floors of dissimilar configurations rather than conceiving the building as a single volume, the architect sought to achieve an articulated block of cantilevered spaces. The multi-level sky-gardens create a rich interplay of shadows on the exterior – cast by the cantilevered elements. The varied designs of its shading system additionally give a dynamic character to the overall envelope.

#### 3.4 'Form' and 'performance'

Mesiniaga's form is related to Yeang's search for a more assertive architectural language during the 'regional' phase of his work. It can be concluded Yeang's regionalist agenda during this period had interfered with his bioclimatic or environmental one. In his introduction to Hawkes' (1996) seminal book 'The Environmental Tradition', Maxwell (1995) [13] gives an insight that provides reconciliation between 'form' and 'performance'. He comments:

*He is thoroughly conscious of the loose fit, that architects know only too well, between form and performance; a space in which **cultural pressures can produce strange distortions.***

Likewise, Mesiniaga's performance can be explained by the force of 'cultural pressures' that impinge on any work of architecture and causes a 'distortion'. Its performance is thus related to the extent of this 'distortion' – which causes a compromise in climatic terms. This can be related to the articulation of an architectural form that would be significant in representing its 'cultural' context. Richards (1993) points to Mesiniaga's success in terms of achieving such a regionalist form:

*The resultant building - an aggregate of Yeang's bioclimatic principles - undertaken within the philosophical framework of modern architecture which is inflected with appropriate regional characteristics of climate and culture - produces a far-Eastern hybrid form.*

This distinctive 'hybrid' form – as described by Berkfield (1994) [14] - is the result of a distinctly architectural intention:

*Most striking is that the Mesiniaga's exterior is neither sealed nor uniform. Mr. Yeang has carved a series of planted terraces, or skycourts as he calls them, into the building. They spiral around the tower's perimeter, providing shaded outdoor sanctuaries and absorbing some of the sun's heat.*

Mesiniaga was awarded the Aga Khan award in 1995 – and became the first highrise in the Eastern context to be awarded this prestigious prize - in recognition to the architect's contribution to the development of regional architecture in Eastern societies. The Aga Khan Masters Jury's comments - which encapsulates the basis of their award (1995) [15]:

*...for having boldly designed a meaningful tall building in a tropical climate. Eschewing the box-like curtain-wall structures so common in corporate office buildings, this project promotes a new language that punches out parts of the structure and wraps a spiralling series of interactive open gardens around the main core of the building. It raises the kind of architectural debate in which the corporate world generally, and the Muslim world, more specifically, can fruitfully engage.*

Peter Eisenman (1996a)[15]– as a member of the jury - commented on the significance of the Mesiniaga not only in terms of its critical regionalist form but also as a 'critical' symbol of a national and collective self-consciousness as it develops from vestiges of colonial administration'. In Eisenman's own words:

*The Mesiniaga is one of the few projects that contribute new thinking to the general culture in architecture...It came out of a particular set of cultural intersections in Malaysia which promotes this kind of activity.*

*We are talking about architecture's symbolic value to contemporary discourse and not whether it functions as a hospital or school. The tower says something about the possibility of a tall building in a tropical climate. All corporate buildings in Malaysia are nightmares of colonial capital implanted in a society.*

It follows that the bioclimatic skyscraper – particularly the Mesiniaga - should be evaluated at two levels i.e. as a critique of homogenous high-rise typeforms within a rapidly modernising context and on another level, in relation to the necessity of 'icons' as symbols of progress in a rapidly developing country in the tropical Asian context.

Due to the patterns of globalisation of the economy in Asian cities, the impacts of the mass media and consumerist values have advanced Western styles into becoming a value and a social norm in these societies - including urban and building design. As a result of this globalisation trend, there is a proliferation of Western forms - representative of a growing capitalist economy. Particularly in the design of large buildings, an 'advanced' image with 'hi-tech', 'intelligent' and 'ultra-modified' features is seen as a pre-requisite for organisations that aim to compete globally.

The adoption of Modernist aesthetics related to homogenous and unornamented envelopes - in conjunction with technologies such as the steel frame and curtain wall - not only produce cost-effective skyscrapers, but fulfil the desire for the Western 'image'. The mass media continuously supports the creation of a 'Western' image. Television and related technologies are heavily infused with Western urban imageries - which consequently impinge upon traditional ways of life and their value systems. Hence

all urban skylines have been increasingly dominated by the International style. In order to maximise land area, high-rise economics seek to have the maximum internal area on each floor (net areas) and the maximum gross building area for site (i.e. maximum plot-ratios and maximum net-to-gross ratios). Colquhoun (1989)[16] observes the link between the highrise and trends in global capitalism:

*There is another phenomenon which might equally be called 'regionalism' that has nothing to do with any vernacular utopia or any critique of industrialization. This regionalism exists as part of unconscious 'ideologies' underlying current practice and is actually connected with political economic survival. It is the result of a complex interaction between modern international capitalism and various national traditions ingrained in institutions and attitudes.*

As part of the cityscape, the ambitions of modernising nations are reflected in urban forms that symbolise progress and modernity. In the context of Malaysia, Bunnell (1999)[17] points to the Petronas Twin Towers as an icon of Malaysia:

*The conceptions of Malaysianness and progress are manifested in a single artefact – the highrise. The building is at once a representation of individual taste as well as broader social and cultural processes, prevailing practices and dominant ideas. Official representations of the building, political and commercial, do powerful work in defining an appropriate vision of the.*

*As cultural landmarks, high-rise buildings 'have been attributed with a significant degree of importance in representing the achievement of the new nations' (Kusno, 2000: p. 198) [18].*

There is thus an imperative towards an assertion of a collective identity against the forces of globalisation. Frampton (1980) [19] highlights this need to promote: *'...a culture of building which, while accepting the potential liberative role of modernization, nonetheless resists being totally absorbed by the global imperative of production and consumption.'*

The importance of form in achieving such an identity is highlighted by Dovey (1999) [20]:

*Despite functional inefficiencies, the corporate tower proliferates primarily because of its role in the symbolic discourse. The building image takes on a renewed economic importance as a primary generator of symbolic capital. Distinction is achieved through a quest for uniqueness of form whether viewed in the city skyline or in relation to neighbouring buildings.*

This reinforces the notion that regional expression is achieved through the poetics of form and reinforces the idea of spatial dynamics as a driving principle behind architectural form. In the context of tropical Asia, Kusno (2000) [18] asserts:

*Southeast Asian identity is achieved by virtue of its continuous involvement with the modernist chain that preceded its appearance as a subject of histories. The construction of 'cultural' difference is thus enabled by the imagined **structure of 'foreign materials'**; a condition enabled to a fundamental degree by a re-articulation of modernist codes.*

Metaphors and icons represent particular means by which regional architects attempt to imbue collective identity and establish a link to existing traditions in terms of architectural form. These provide a mechanism by which 'local' culture can be reflected in such new building forms. The aim is to be critical of modernisation while refusing the abandon traditional forms and values – where tradition should be combined with the progressive aspects of the modern development.

#### 4. YEANG'S ACHIEVEMENT

The highrise - in particular - is an entity that represents a symbol of 'wealth' and achievement. Within an urbanising economy where pressures of increased land values, urban accessibility, expanding urban populations and the globalisation of national economy converge, these modern type-forms have proliferated due to such economic, social and technological forces. They are consequently shaped by the combination of these factors - including central land prices, corporate needs and engineering expertise.

An 'ethical' position for the design of large buildings - such as the highrise - can be argued as one that should encourage alternative but culturally-differentiated forms that contribute to the formation of locational identities in rapidly developing cities. The tall building is a product of such determining and overwhelming forces such as economics, law, structure and technology associated with the global economy. The priority in the case of large buildings – under such conditions should be, as described by Herkert (1999) [21] :

*...to generate solutions not only within the narrow bounds defined by the characteristics of the archetypical form but to introduce a new style which differs radically from the prevalent archetypical style.*

#### 5. CONCLUSION

While the overall forms of the Plaza IBM and Menara UMNO are respectively linked to the 'tropical archetype' and the 'bioclimatic prototype' during their respective periods, Mesiniaga's form on the other hand, is linked to Yeang's more 'cultural-iconic' intentions during its period. These intentions follow from Yeang's search for a distinctive regional form during the late 1980s and the increasingly 'symbolic' role of highrises in Malaysia in the 1980s and 1990s.

In terms of language, PLAZA IBM can only be described as characteristically a restrained one. Its performance is linked with the underlying philosophy or intentions behind its form. Its philosophy is essentially characterised as a position based on 'climatic regionalism'. Yeang's regionalist 'inflections' during this period – i.e. the 'iconic' roof, the wedge-shaped upper floors and the 'weaving' landscaping - were part of an attempt to regionalise the underlying rigorous bioclimatic 'order' – based on the idea of the 'tropical archetype' under the Malaysian climate.

Mesiniaga's more assertive language is in contrast with the restrained language of the Plaza

IBM and the UMNO. Its overall form can be described as more exuberant and heroic - the architect aimed at iconic expression and sought to establish the primacy of its symbolic expression. A similar 'heroic' posture is demonstrated in another bioclimatic highrise design of the same period i.e. the MBF tower in Penang.

The evolving theories of the bioclimatic skyscraper thus can be explained as a continuous position which oscillates between the 'climatic' regionalism of IBM and UMNO to the cultural/iconic assertiveness of the Mesiniaga. Their performances are thus related to Yeang's regionalist position - which oscillated between these opposing poles. The theory and design of the Mesiniaga can be seen as a point of convergence between the two agendas or tendencies which creates a maximum tension between 'climatic' and 'cultural/iconic' intentions or 'poles' within Yeang's position.

This position can be argued as that which achieves a minimum compromise in climatic or environmental terms, in order to achieve a culturally-differentiated form symbolic or representative of its particular cultural context. His achievement thus lies with this 'minimum' level of compromise - linked to a achieving a collective significance amidst the need for cultural-consciousness within a rapidly developing nation. The theories and designs of Ken Yeang thus embodies a continuous tension - between romanticist tendencies based on 'nature and culture' and a rationalisation of design based on methods of science. The bioclimatic skyscraper is thus representative of Yeang's continuous attempts to reconcile the resource-consuming nature of the high-rise entity with the resource-conserving philosophy of his life's mission outlined in his PhD. The importance of the study of the theories and designs of Ken Yeang is highlighted by Lawson (1994) [22]:

*He represents a designer who thinks about implementing an investigative theoretical agenda for his practice and about how to manage people so that agenda can continue to be realised. He continues through design to research and develop his thinking about issues of his choice, he satisfies his clients and produces award-winning architecture. The fact that he achieves this with a socially and culturally responsible agenda and by working almost exclusively with highly commercial clients suggests that this process is certainly worth our attention.*

## ACKNOWLEDGEMENTS

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