

Archetypal Layout: Extending the Concept of the Archetypal Building to Streets and Block Layout

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Introduction

This paper sets out to explore the possibility of extending Steadman's concept of the archetypal building (Steadman 1998, Steadman and Waddoups 2000) to streets and block layout. This is part of a wider study of the specification of urban form and patterns, within the EPSRC funded *SOLUTIONS* project (Sustainability Of Land Use and Transport in Outer NeighbourhoodS).

The ultimate purpose is to see if an 'archetypal' representation of street layout could assist with the analysis of existing urban layout patterns, and with the specification of designs for future layout patterns (whether for a specific site or for generic design guidance).

First, the paper develops a possible archetypal format for codifying the layouts of houses and plots. Examples of application to actual layouts are presented. Measures of ground coverage and density (floor space index) are calculated for these cases, using a simple spreadsheet model. Possible extensions to street type and urban layout (as previously suggested by Marshall, 2005) are then discussed.

An archetypal representation of housing layout

Imagine a highly schematic representation of the plan of a rectangular building on a rectangular site (Figure 1). (We will come to more complex cases shortly.) The building is the grey rectangle at the centre. The green cells represent open space or garden on the

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four sides. At the top is an access road. Let us make a conceptual separation between the *configuration* of the plan, and its *dimensions*. We assign dimensional parameters x_1, x_2, x_3 to the widths of strips of land across the plan in x , and parameters y_1, y_2, y_3 to the widths of strips in y . We can then give these parameters any values we like, to obtain an infinity of differently dimensioned plans, but all sharing the same essential layout. In the diagram of Figure 1 all the values are equal. The plan is then *dimensionless*. By this means we have in effect separated configurational from metric properties.

Suppose now that we were to give certain of the dimensional parameters the value zero. Then the relevant strips of land would disappear. We can introduce a simple method of encoding, whereby if a strip is present we give the value one, and if the strip is absent we give a zero. This is shown in Figure 1. Another way of thinking about this coding is to notice that if *either* the x or the y value for a cell is 0, then that cell disappears; but if *both* x and y values are 1, the cell is present.

The result in the case of Figure 1 is the plan of a building with open spaces at back and side. We can set the 0s and 1s in order, by convention, with the x values first, followed by the y values, to create a 6-digit binary code. In the figure the x and y dimensions of the building itself are shown in red. If either of these values is zero then the building itself disappears. Such cases are obviously not interesting as building layouts.

Figures 2, 3 and 4 show examples of the plans of house types encoded using this convention. Figure 2 illustrates 19th century back-to-back houses in Liverpool (Muthesius 1982). Here there is no open space on any of the four sides of the house, so the code is 010010. Two such units can be packed back-to-back of course, with roads on opposite sides, and pairs of units packed laterally, to form the characteristic larger blocks of houses. Figure 3 shows what might be termed ‘quarter-detached’ houses in Wakefield (Muthesius 1982), each one of which has a small piece of open space at one side. These pack together four to a block, again with access via roads or alleys on two opposite sides. Figure 4 shows some rather more elegant quarter-detached houses by Frank Lloyd Wright

which again pack together in fours, but where each house has garden on two adjoining sides.

Each of these house types, with their associated open spaces, has a distinct six-digit binary code (Figure 5). All six-digit binary numbers can be listed. Of these we need only consider those in which there are 1s in the second and fifth places, as explained. There are only sixteen such numbers, and between them they serve to enumerate *all possibilities* of arrangement, within the terms of the representation (Figures 6, 7). Starting from back-to-backs, they go through different types of terrace house with gardens at the back, or at front and back; through the ‘quarter-detached’ types; through different types of semi-detached; and finally to detached houses completely surrounded by gardens. It will be clear that the coding captures and formalises two attributes that form the basis of the conventional everyday terms for house types: how they share party walls (or not) with adjacent houses, and on which sides the exterior walls are exposed and can obtain daylight and ventilation. These attributes in turn constraint internal room layout.

This simple archetypal layout adopts some of the basic ideas implicit in Steadman’s archetypal building (Steadman 1998, Waddoups and Steadman 2000). The plan of the archetypal built form is made up from strips not of land but of accommodation or built space - whether these be rows of rooms lit from the plan’s perimeter, strips of internal artificially lit space serving for example as corridors, or rows of rooms day-lit from courts (Figure 8). These strips of accommodation can all be assigned dimensions of width. Strips can be removed by setting their dimensions to zero. Different plan configurations for buildings can be encoded as binary numbers, and possible plans enumerated. In effect, the archetypal building represents a kind of *maximal form* from which a great variety of other built forms are obtained, through a process of subtraction, or carving. The main differences from the archetypal house layout are that the archetypal building is represented and encoded in three dimensions; and in the current operational version is based in plan on a 15 x 15 grid of cells whose binary codes are thus 30 digits in length. (But it is still practical to enumerate possible codes – see Waddoups (2001).)

A spreadsheet model of actual housing layouts

Going back to housing layout, Figure 9 shows a slightly more elaborate representation, with configuration once more separated from dimensions. Extra strips of land are introduced, including a pavement along the road, and a mews or alley at the back. The house or building itself is now represented by a 5 x 5 array of twentyfive cells, the centre cell of which is a courtyard. The strips of accommodation within the building obtain their light respectively from the exterior, or from the court. This makes it possible, obviously, to model simple courtyard houses; but it also allows for the L-shaped plans that are typical of many small houses. Again one should imagine this whole layout mirrored about the axis of the mews, and translated laterally, to produce repetitive patterns of similar houses. Binary codes could be derived as before, but now their length would be 17 digits not 6. (Even so, it would not be out of the question to enumerate all possibilities.)

We have operationalised this layout model as an Excel spreadsheet, into which both the binary codes and actual values for dimensions can be entered. These include values for the number of storeys in the building, and the storey heights, so that total floor area, volume, and the areas of walls can be computed. Several measures of overall geometrical ‘performance’ are then calculated. These include the ratio of volume of the house to its surface area, and the ratio of external wall area to floor area – both measures that could be of interest in relation to lighting and heating. More relevant for the present discussion are two measures of density, both of them expressed as floor space indices (FSI = total floor space/ ground area). We calculate *net FSI*, counting just the area of the plot; and *gross FSI* including the areas of alley, pavement and half the width of the road. The final measure is *ground coverage* (area of the building footprint/ plot area).

We have taken a small and utterly random selection of existing and historical layouts, just to illustrate the kinds of results produced by the model. These include two designs of tenement from late 19th century Manhattan, one of them the notorious ‘dumb-bell’ type,

as instances of some of the highest densities ever achieved in walk-up housing (Riis 1971). We have modelled the Liverpool back-to-backs (Figure 2). And we have taken examples of 19th and 20th century terrace, semi-detached and detached houses from the town of Swindon. Figure 10 for example shows typical byelaw terraces in Swindon, with houses, streets, gardens and back alleys colour coded. With the semi-detached houses shown in Figure 11 there is somewhat less regularity of layout: in particular the wedge-shaped gardens depart, clearly, from the constraints of orthogonal geometry. We will come back to this issue. Figure 12 shows semi-detached and detached houses mixed, with a variety of sizes and shapes and gardens. For the model we have taken average dimensions for the row of houses and gardens to the north of Sarsen Close.

Notice how in Figure 12, despite this being a large and deep block, the essential *topology* of our simple archetypal layout is nevertheless preserved. There is still a series of parallel if sometimes curving strips of land and building, always in the same order: road, pavement, front garden, house, back garden. The same sequence of strips is then mirrored in the opposite order: the heavy lines shows where the pattern reverses. One could imagine the whole pattern being ‘torn apart’ along these lines, and straightened out, without its essential functioning being impaired.³ The whole band of parallel land uses may be bent and curved to fill the complete block, but the ordering of the strips relative to the roads is unchanged. This is a characteristic of the great majority of post-19th century housing layouts.

Figure 13 gives computed values on a linear scale for the *ground coverage* of the various modelled types. The ordering of the values is not very surprising, from 0.04 for the largest detached houses, to 1 for the Liverpool back-to-backs, which have no open land within their plots. Figure 14 gives values on a linear scale for *densities*, calculated as gross floor space indices. We have in mind the possibility that with a larger sample of measured layouts, it would be possible to establish *ranges* of density, characteristic of each of the various house types and layouts. Some theoretical experiments with

³ But small boys could not then get through holes in the hedges at the bottom of their gardens into the gardens opposite.

systematic changes to dimensional parameters would also be possible. The variables that are likely to have the largest effects are garden sizes, obviously, but also numbers of storeys. (In Figures 13 and 14 the number of storeys is not controlled for, and the back-to-backs and tenements achieve their high densities in part by going up to four, five and six storeys, compared with two or three storeys for the Swindon houses.) Other dimensions would vary within narrower ranges, as for example road and pavement widths, and the depths of houses in plan, which tend to lie between 7 and 10m because of the typical sizes of domestic rooms and the general requirement for daylight (Brown and Steadman 1991). Such ranges of feasible density for each type would overlap, as they do in Figure 13.

It would be possible, we believe, to use this kind of approach to get a better and more structured understanding of the relationships between key dimensional variables, building types, and land use performance. Values for floor space index could of course be converted, with suitable multipliers, into dwellings per hectare or persons per hectare. In the context of *SOLUTIONS*, such results could possibly form a bridge between the aggregate estimates of floor space made by land use/ transport models, and the implications these have for the more detailed scale of urban design. Predicted floor space and densities might be translated, that is, into their likely consequences for generic built form.

Extensions of the simple layout model

There are clear limitations of the layout model as described so far. It is confined to an orthogonal geometry; and it assumes an indefinite repetition of the identical plot and house type. Extensions of the same principles to rectangular blocks of finite size containing a mixture of building types is relatively straightforward, as in a recent study of high-density housing in Hong Kong (Steadman and Kvan, forthcoming). This work treated rectangular blocks with special types of plots and buildings at the corners or ends of the block. The analysis made use of a spreadsheet model of block layout similar to that described here, and used the archetypal building to model the built forms of the

apartments themselves. This allowed for more complex shapes and forms of buildings than those treated above.

The general approach faces larger difficulties with the kinds of non-orthogonal block illustrated by the example of Figure 12. We have already observed however that certain *topological* regularities tend to be preserved in such layouts. These regularities might be exploited in a more general methodology. They are present – although often unrecognised - in the urban fabric as a whole, and are manifested through the spatial logic of the street. They have to do with the way that urban structure is fundamentally constituted by a contiguous web of public routes whose islands may be likened to an archipelago (Figure 15). Put simply, every public street, road and path is connected to each other in a single contiguous structure. Urban blocks, plots of land and buildings effectively form islands (cf. Roman *insulae*, or French *îlots*) set in this ‘sea’ of public street space. This gives the street a fundamental organisational logic – that is recognised, incidentally, even by authors of a book on the urban *block*:

“This focus on the urban block... does not imply that we regard it as the primary element in the production of urban form. From a morphological point of view... this role is played by the street as that element of the public space system that structures settlements.” (Panerai *et al.*, 2004:168).

The linear nature of this organisational logic is described in more detail in Marshall (forthcoming) who identifies three basic rules or ‘laws’ of urban topology. These are suggested as being typical tendencies, generally holding true, though with exceptions in special circumstances:

1. Rule of contiguity of public space: all public space is connected up in a single contiguous system. This means that there are no isolated pockets of public space surrounded by private space;
2. Rule of adjacency of private space: all private space connects to public space; the private always plugs into the public, i.e. public space forms the continuum into which individual private plots plug, not vice versa. This means that every private plot of land

may directly access public space without having to go through any other owner's private land. (The rule was however frequently broken in cities before the introduction of motorised transport);

3. Law of gravity, or rule of contiguity of buildings with the ground plane. This rather obvious condition (yet one necessary for completeness) assures that all urban floor space ultimately connects to a single plane, the ground plane, and is organised according to the preceding two rules.

At the micro scale of street layout we may further add:

4. Footways always tend to be at the side of vehicular carriageway (not in the middle) – hence, lying between (and acting as an interface between) the private plots and the vehicular carriageway;

5. Hence all private land tends to plug directly into pedestrian-accessible public routes.

So there is a definite 'meaningful' order or structure which may be said to echo the way that building form has certain 'rules', as embodied in the archetypal building. As a result, the urban fabric has a distinctive crinkled, crenellated form (Figure 16). It is constituted by streets that are effectively arranged according to rules relating to buildings needing to have surfaces exposed to light, for private plots to connect to the public streets, and for public streets to all connect up. A city is not like a huge building (Marshall, forthcoming). Thus, even though street patterns themselves are in some ways more irregular, complex, curvilinear and unique than building plans, there is nevertheless a definite, exploitable linear logic about them.⁴

So the unit is the street or rather street cross-section – a vertical slice that may be swept laterally to create a horizontal prism – echoing the way that a (horizontal) building plan is projected upwards to create a vertical prism. A street may vary in character, land use, distance between unit widths along its length, just as a building may vary in character,

⁴ This reducability to a linear logic is not inevitable: if we imagine trying to apply it to a room, say a living room or bathroom, then it is not necessarily clear what is or is not an actual circulation passage (between the sofa and the wall? stepping into the bath?) and which bits of the 'hinterland' are definitely associated with which spaces. Also a stool is accessible all round, not connected uniquely to a particular (recognizably linear) space.

use and distance between storeys. If a heterogeneous built form may yet be coded or represented as part of an archetype, then surely a heterogeneous street may be. (But this depends on how irregular these streets are in relative terms, since over a certain degree of heterogeneity the description becomes almost as long as the thing it is representing.)

Just as each building is necessarily ‘earthed’ i.e. attached to the ground (the third law of urban topology), each street is ‘earthed’ – connected to the public network – at least one point, usually one or both ends. And although streets need to be connected up to form a network, dealing with individual streets on a street-by-street basis is no different from dealing with the form of buildings on an individual basis. Overall, the point here is that the urban fabric as a whole can be regarded as being organised by a system of linear streets: each part of the urban tissue can be associated with a given street or route, since all contiguous urban land may be associated more or less directly with a given public route. (This relates to the street address system, where any building may be uniquely identified by the public road it is accessed from.)

This means that if we can create a general representational model or archetype of the street – that can capture any type of street, to any desired degree of resolution – then it will be possible to represent any portion of urban area as an appropriate array of streets. Here ‘street’ is taken to mean the public road and footways, plus the adjoining land, this associated ‘hinterland’ including buildings, gardens, and so on, that is given access to from the street. The arrangement can be visualised by imagining an urban plan to have a series of potential *tears* in it, as we illustrated (and marked by heavy black lines) in Figure 12. These tears lie typically along the rear boundaries of plots, walls between back gardens and so on (Figure 17). They split apart the urban tissue into tracts of land associated with different routes. Once this is done, it is easy to imagine the pieces of associated land converted into a linearised representation (Figure 18), which may be represented by a street archetype.

In this way, although street layouts themselves are not always rectangular, nor are they regular in a configurational sense, they are nevertheless made up of linear strips or

corridors, which although two-dimensional on the ground may be represented as linear arrays, corresponding to the familiar device of the street cross-section (Figure 19a). The figure shows a series of strips of land as in the simple layout models described earlier. Just five land uses are represented: buildings, front gardens, footways, carriageways and a median strip. The presence or absence of any strip can be denoted by a 1 or 0 as before. The widths of the strips within this ‘archetypal street cross-section’ can then be assigned dimensions to produce some actual geometry. Figures 19b and 19c show how, from the archetype of Figure 19a, it is possible to select strips and give them dimensions, so as to represent streets of quite different size and character. Figure 19b shows a single carriageway with a narrow garden on one side only Figure 19c shows a wide street with buildings on one side and gardens on the other – as for example Princes Street, Edinburgh. The corresponding binary codes would be 11110101 and 101111110.

Now along the *length* of a street, each such strip (cross-section) will only last (at least in a specific dimensioned form) for as long as there is a constant breadth. It implies a new strip section for each change in any of the breadths denoted in the representation, although for purposes where the dimensions are not critical (e.g. for purposes relating only to street type, e.g. boulevard, residential street, etc.) then fewer sections would be needed to represent the general type. In a situation where an archetype was being used in a prescriptive sense for specifying the layout of new-build streets (rather than describing existing streets) then streets of constant breadth may well be reasonably common. The archetype could be further developed by including the buildings behind the street frontage, and their ‘hinterland’ (back gardens and so on) as in the layout models described earlier; or by allowing for further subdividing carriageways and lanes, e.g. to represent presence of bus lanes, tram track reserves, multiple carriageway boulevards, and so on.⁵

We envisage that in some way – although this is not entirely clear to us yet – this street profile might be ‘swept’ along the length of a street, the encoding and dimensions

⁵ Back lanes consistently running parallel with the main street might also be included as part of the hinterland of the main street in some circumstances; in other cases, these might be represented separately, i.e. as separate streets.

changing as different arrangements of building and land use were encountered. Total land areas might be calculated by integration along the ‘swept’ route. There are at least two major issues here. The first is the difficulty of coping with non-straight and especially curving streets, and the fact that the land uses to which contiguous streets give access must pack to fill the entire land area by means of non-orthogonal plot shapes, as in Figure 12. The second issue is that, as the numbers of elements (strips) represented by the archetype increases, so the binary codes get longer, and it becomes increasingly impractical to enumerate possible arrangements. One principal motivation in the design of the archetypal building was to produce a representation – despite the limitations it imposed – which was at a sufficient level of abstraction to allow the possibility of listing and searching all binary codes, and hence finding all built forms.

Perhaps part of the answer, for street and block layouts, might be to move to an even higher level of abstraction in the representation. Maybe many plots of private land could be aggregated together as simple bands on either side of the road, and defined just by ‘land use’. Hence ‘semi-detached with front and rear garden’ would not be represented explicitly (configurationally) in the archetype, but would simply appear as a ‘land use type’ distinct from, say, ‘terrace with back garden’. (Gross properties such as density, ground coverage etc of these bands could be calculated independently with the types of model described earlier.)

Thus any street plan might be ‘reduced’ to a network of linear elements (Asami *et al.*, 2001) – as in fact is ‘naturally’ done by transport planners, except that the linear element is not now just the vehicular artery, but includes the ‘hinterland’ of the adjoining land uses. In this way, the difference between an archetypal skeletal network and a conventional (transport) network is that the archetypal representation builds in the adjoining land uses to the linear element, whereas in a conventional transport model, the land uses are considered to form separate zones, that may or may not be connected individually to the network (Figure 20).

This means that the conventional transport planner's simplification – reduction to a skeletal network – is not (just) a 'crude' simplification (involving a loss of resolution) but is also a 'critical' simplification (or selective representation, a top-level structuring device) in the way that a ground plan or urban plan showing building footprints is a critical simplification of three-dimensional urban form. In other words, if one is going to take a single planar slice through the 3D urban fabric, then the 'critical' way of doing this (to best effect, revealing most functional meaning) is normally at the level of the ground surface, as opposed to a planar slice at any angle. Similarly, if one is going to abstract a single land use from a town plan, the most revealing single land use is likely to be that representing the public street network (or if one cares to make the distinction, the pedestrian network). As a result, descriptors of urban form based on street network characteristics have a significance that goes beyond their relevance to transport.

Conclusions: potential applications

This paper has demonstrated application of the archetypal format of representation for codifying the layouts of houses and plots, and suggested possible extension to the codification of street type.

As noted earlier, it would be possible to use this to better understand the relationships between urban form characteristics such as building type and land use performance, and relate these onward to issues of density. This in turn could help to relate between other parts of the *SOLUTIONS* project, such as land use / transport modelling and urban design at the local scale (e.g. WP2 and WP3).

The development of an 'archetypal' system for classification of street type – based on frontage land use and/or building type – could help characterise urban form, at the scale of the district (or even larger area). For example, a whole district could be described as being constituted by residential terraced streets. Here, the street type (embodying land use and building type) is effectively representing the character of the whole district. This could contribute to the *SOLUTIONS* work on pattern specification (WP4).

Finally, it would be possible to develop the latent linkages between coding as a descriptive exercise and coding as a generative or prescriptive exercise. This paper has been primarily concerned with the former. However, there is potential for linking such a system of coding onward explicitly to ideas of generative or ‘morphogenetic’ processes (which may themselves be interpreted in diverse ways, e.g. Hillier, 1996; Alexander, 2002; Batty, 2005) and ultimately to ‘design coding’ used in design guidance or regulation – currently being tested in practice in the UK (CABE, 2005; Carmona *et al.*, forthcoming). These linkages are to be explored further within *SOLUTIONS*, in the Urban Structuring workpackage (WP15).

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