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A Computational Investigation into the Fractal Dimensions of the Architecture of Kazuyo Sejima

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Abstract: In the late 1980's and early 1990's a range of approaches to using fractal geometry for the design and analysis of the built environment were developed. Mandelbrot's "box counting" approach was later refined and developed by Carl Bovill (1996) who demonstrated a method for determining an approximate fractal dimension of architectural elevations and plans. This paper is the first investigation of the fractal dimensions of five house designs by Kazuyo Sejima, a famous, late 20th century minimalist designer (Aoki 2003; Hasegawa 2006). The fractal dimensions are calculated using a combination of Archimage and Benoit software, the former of which uses an extrapolation of Bovill's box-counting method for the fractal analysis of house designs. Significantly, past research using the box-counting approach has only been applied to the works of Frank Lloyd Wright, Le Corbusier and a limited selection of ancient buildings. This paper will not only expand the set of cases tested by adding a selection of late Twentieth Century examples, but these will also be the first examples of minimalist architecture tested by this method. This paper will conclude by first providing a discussion of the five houses of Kazuyo Sejima, with a comparison between their design features and their box-counting results. Second, a brief description will be presented of how the fractal geometry of Sejima's architecture differs from that of other architects' works recorded in past research.

Keywords: Fractal Architecture, Computational Tools, Design Assessment, Kazuyo Sejima

Introduction

CARL BOVILL'S 1996 application of Mandelbrot's "box-counting" approach demonstrates a method for determining the approximate fractal dimension of architectural plans and elevations. This method is useful because, in architecture, there are only a limited range of quantifiable approaches to the analysis of the visual qualities of buildings and landscapes. Bovill used the box-counting method to analyse the architectural forms of Frank Lloyd Wright's Robie House and Le Corbusier's Villa Savoye. Bovill also used this method to analyse vernacular architecture, as did Bechhoefer and Appleby in 1997 and Burkle-Elizondo, Sala and Valdez-Cepeda (2004) used this method to analyse ancient architecture. Bovill also showed how the box-counting method could be used to analyse urban layouts and landscapes; an approach that has been repeated by Makhzoumi and Pungetti (1999).

Although others have used Bovill's approach, any evidence of the testing of this method and its parameters is rare and the comparisons Bovill makes between buildings have rarely been considered (Lorenz 2003). Ostwald, Vaughan and Tucker (2008) began to address this deficiency when they undertook a detailed examination of the method, re-tested Bovill's

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original results for the Robie House and the Villa Savoye, and expanded the set of cases to include five houses by Frank Lloyd Wright and five by Le Corbusier. In the present paper the fractal dimensions of the elevations and plans of five of Kazuyo Sejima's houses are calculated using TruSoft's *Benoit* (vers. 1.3.1) program and *Archimage* (vers. 2.1). The following sections explain what is meant by fractal dimension and provide an overview of the box-counting method. The possible uses of fractal analysis in architecture are then outlined. Thereafter, the paper describes how the present study was undertaken and a background to Sejima's work in general, and the five houses in particular. The paper concludes with a review of the results of the study and any questions raised by these results.

Fractal Dimension

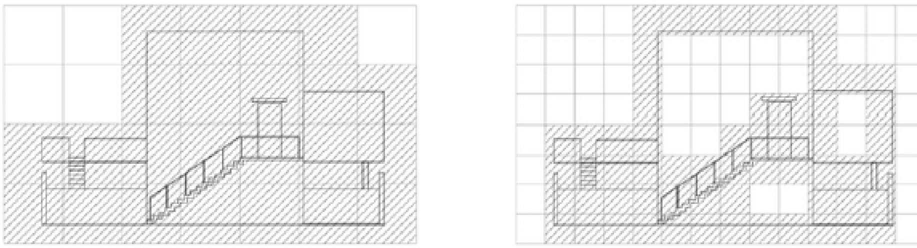
Fractal geometry describes irregular or complex lines, planes and volumes that exist between whole number integer dimensions. This implies that instead of having a dimension, or *D*, of 1, 2, or 3, fractals might have a *D* of 1.51, 1.93 or 2.74 (Mandelbrot 1982). One method for determining the approximate fractal dimension of an object is to apply the box-counting approach. Consider a drawing of an elevation of a house. A large grid is placed over the drawing and each square in the grid is analysed to determine whether any lines from the façade are present in each square. Those grid boxes that have some detail in them are recorded. Next, a grid of smaller scale is placed over the same façade and the same determination is made of whether detail is present in the boxes of the grid. A comparison is then constructed between the number of boxes with detail in the first grid and the number of boxes with detail in the second grid; this comparison is made by plotting a log-log diagram for each grid size (Bovill 1996; Lorenz 2003; Ostwald, Vaughan, Tucker 2008). By repeating this process over multiple grids of different scales, an estimate of the fractal dimension of the façade is produced. While this process can be done by hand, the software programs *Benoit* and *Archimage* automate this operation.

There are many variations of the box-counting approach that respond to known deficiencies in the method. The following points describe how the present research responds to each issue.

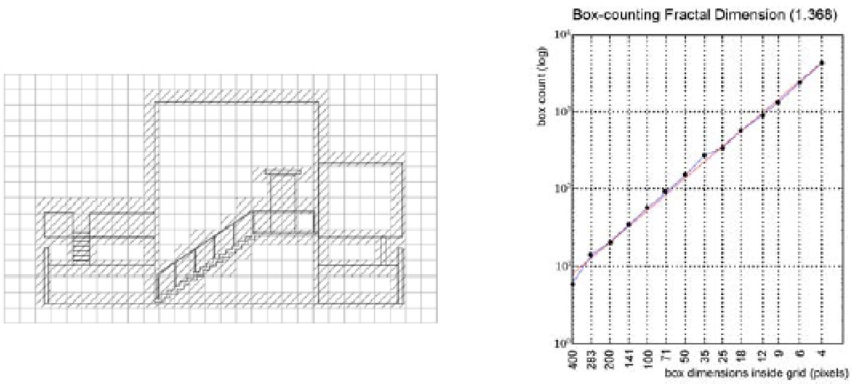
- *White space*. The volume and distribution of white or empty space around the source image can alter the result. Careful sizing of the initial images in combination with divisible grid solutions (described hereafter) limits the impact of this problem.
- *Image proportion*. Sometimes the original image must be re-proportioned to ensure that a divisible grid is able to be determined. *Benoit* solves this problem by cropping the image size to achieve a whole-number starting grid. *Archimage* enlarges the image by adding small amounts of empty space to the boundaries. While neither of these variations changes the elevation in the source image, they produce subtle variations in the resultant *D*.
- *Line width.* The wider the lines in the source image, the more chance they have of being counted twice when grid sizes become very small, leading to artificially increased *D* values. To counter this situation, *Archimage* software pre-processes images using a line-detection algorithm that reduces all lines to one pixel width. *Benoit* overcomes this problem by allowing the analytical grid to be rotated or resized to minimize the impact of line weight.
- *Scaling coefficient*. The factor by which successively smaller grids is produced is called the scaling coefficient. Bovill, in his original examples, halved the grid dimension for

each comparison (a ratio of 2:1) whereas *Benoit* and *Archimage* use a lower scaling coefficient (a ratio of 1.3:1) to more gradually reduce the grid size and generate a more accurate result.

- *Statistical divergence*. The average slope of the log-log graph may be the approximate *D* value, but the points generating the line are not always consistent with it. For the present research, initial trials allowed similar settings for starting grid proportion, size and scaling coefficient to be chosen that minimise the number of divergent results.



Figures 1 and 2: First Grid (Left) and Second Grid (Right) Placed Over Elevation 1 of the Y-House Showing Box-counting



Figures 3 and 4: Third Grid (Left) Placed over Elevation 1 of the Y-House Showing Box-counting. Log-log Diagram (Right) of the Comparison between the Number of Boxes Counted in a Grid and the Size of the Grid (*Archimage* Result for Elevation 1 of the Y-House)

Fractal Dimensions and the Built Environment

Carl Bovill (1996) suggests that fractal progression in architecture is "necessary to maintain interest" and that "the lack of textural progression could help explain why some modern architecture was never accepted by the general public. It is too flat." (5-6) Compared to traditional, vernacular buildings, Bovill states that "Modern housing seems to have lost the ability to create this cascade of interest." (149)

Bovill does not offer any further explanation for this assertion apart from alluding to "flat" modern architecture as lacking a certain level of "order and surprise". According to Bovill, levels of complexity will affect visual preference because the natural world (which is considered to be highly fractal) surrounded people during the evolution of human perception. Bovill concludes that therefore humans appreciate surroundings which have a higher fractal dimension. (Bovill 1996:116) Although Bovill did not fully explore or test these ideas, studies have been undertaken by others on visual preference in relation to the visual complexity of buildings.

Heath, Smith and Lim have undertaken several studies on peoples' visual preferences for types of tall buildings. In 1993 a synthetic skyline generator was developed (Lim and Heath 1993) which was then used to study peoples' preferences for tall buildings based on the relationship between dimensions and separation of tall buildings (Smith, Heath and Lim 1995). In 2000, further studies analysed the response of a similar range of people to varying levels of complexity in artificial skylines. Heath, Smith and Lim (2000) concluded that the more complex the skyline, the more aesthetically pleasing it would be found to be. This testing relied on qualitative and quantitative measures of complexity and did not utilise fractal geometry to analyse or test the visual complexity of the images.

Fractal geometry has been used to analyse preferences for the visual complexity of art (Taylor 1998; 2006), computer generated random images (Sprott 1993; Aks and Sprott 1996; Pickover 1995) and the skylines of buildings and natural landscapes (Stamps 2002; Hagerhall, Purcell and Taylor 2004). Each of these projects resulted in a numerical range of preferred fractal dimensions. Hagerhall, Purcell and Taylor's (2004) study of skyline preferences found (in a limited range) a preference for a fractal dimension value of D =1.3, as did Sprott's initial research on the aesthetic preference of visual complexity found in computer generated strange attractor images. Sprott's results uncovered a preference for fractal dimensions in the range of $D = 1.3 \pm 0.20$ (Sprott 1993). Later in conjunction with Aks, they further found that participants displayed preferences for fractal dimension with a range between 1.17 and 1.38, with an average preference for 1.26 (Aks and Sprott 1996). In 2006, Taylor published results showing that the fractal dimension range between 1.3 and 1.5 resulted in a least stressful physiological response (via a skin conductance test) for viewers of images artworks, photographs and artificial patterns. In a separate study, Pickover also investigated "patterns of aesthetic value" (Pickover 1995:204) this research, presenting hundreds of computer generated recursive lattice patterns to viewers, showed a preference for a D value of 1.8 (Pickover 1995:206). While determining visual preference for D values is outside the scope of this present study the range of values recorded in these previous studies is of interest to the people researching the fractal analysis of architecture.

Another use of fractal dimensions in architecture is described by Stamps as "contextual fractal fit" (Stamps 2002:163). As Robertson notes, the box-counting method can be used to calculate the fractal dimensions of urban forms in order to compare them with other urban areas or to integrate them into a wider regional area (Robertson 1995:13). Bovill provided examples of this idea in his 1996 publication and Ostwald and Tucker further explored the implications of using the box counting method in this way, to inform local councils of the degree to which a new building proposal for a region will be a "good" contextual fit for the region's or the neighbourhood's characteristic visual complexity (Tucker and Ostwald 2005; Tucker et. al. 2006).

Analytical Method

Five of Kazuyo Sejima's houses in Japan are the focus of the present study. They are: Y-House (1994), S-House (1996), M-House (1997), Small House (2000) and House In A Plum Grove (2003). New drawings of Sejima's houses were prepared for the analysis, each with consistent graphic conventions and scale. The lines in each drawing typically record changes in form, not changes in surface or texture. Thus, major window reveals, thickened concrete edge beams, and steel railings are all drawn, while brick coursing and control joints are not. In most cases four elevations were developed for testing. In the case of the M-House, there is only one elevation; the remainder are hidden or common walls in a dense streetscape. For the M-House only the one visible elevation was used for analysis.

The standard method for the fractal analysis of visual complexity in houses is as follows (Ostwald, Vaughan and Tucker 2008).

1. The drawings or views of each individual house are separately grouped together and considered as a set.
2. Each view of the house is analysed using *Archimage* and *Benoit* programs producing, respectively, a $D_{(\text{Archi})}$ and a $D_{(\text{Benoit})}$ outcome. The settings for *Archimage* and *Benoit*, including scaling coefficient (determining the ratio by which grids reduce in scale) and scaling limit (the smallest grid where data is collected), are preset to be consistent between the programs. *Archimage* results are typically slightly higher than those produced by *Benoit* although the variation is consistent.
3. The $D_{(\text{Archi})}$ and $D_{(\text{Benoit})}$ results for the elevation views are averaged together to produce a separate $\mathrm{D}_{(\text{Elev})}$ result for each program for the house. These results are a measure of the average fractal dimension of the exterior facades of the house. Past research suggests that $\mathrm{D}_{(\text{Elev})}$ results tend to be relatively tightly clustered leading to a high degree of consistency.
4. The $\mathrm{D}_{(\text{Elev})}$ results produced by *Archimage* and *Benoit* are averaged together to produce a composite result, $\mathrm{D}_{(\text{Comp})}$, for the house. The composite result is a single *D* value that best approximates the characteristic visual complexity of the house.
5. This process (steps 2 to 5) is repeated for each house producing a set of five $D_{(\text{Comp})}$ values. These values are averaged together to create an aggregate result $D_{(\text{Agg})}$ which is a reflection of the typical, characteristic visual complexity of the set of the architect's works.

Importantly, this method does not produce a *D* result for the three-dimensional form of the house rather, it generates a series of average *D* results for the two-dimensional visual qualities of a structure (Table 1 contains a summary of abbreviations).

Table 1: Abbreviations and Definitions

Abbreviation	**Meaning**
D	Approximate Fractal Dimension.
$D_{(Archi)}$	*D* calculated using *Archimage* software
$D_{(Benoit)}$	*D* calculated using *Benoit* software.
$D_{(Elev)}$	Average *D* for a set of elevation views of a house using a specified program.
$D_{(Plan + Elev)}$	Average *D* for a set of elevation and plan views of a house using a specified program.
$D_{(Comp)}$	Composite *D* result averaged from both *Archimage* and *Benoit* outcomes for the elevations of a house.
$D_{(Agg)}$	Aggregated result of five composite values used for producing an overall *D* for a set of architects' works.
$IS_{(Pix)}$	The size of the starting image measured in pixels.
$LB_{(Pix)}$	The size of the largest box or grid that the analysis commences with, measured in pixels.
$G_{(\#)}$	The number of scaled grids that the software overlays on the image to produce its comparative analysis.

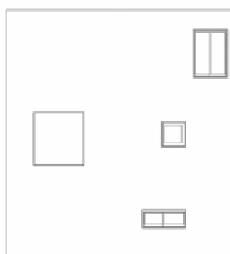


Figure 5: House in A Plum Grove Elevation 4 D 1.244 $_{(Archi)}$ and 1.200 $_{(Benoit)}$

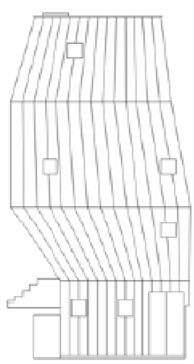


Figure 6: Small House Elevation 1 D 1.629$_{(Archi)}$ and 1.517 $_{(Benoit)}$

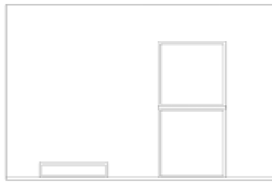


Figure 7: S-House South Elevation D $1.363_{(Archi)}$ and $1.233_{(Benoit)}$

Kazuyo Sejima and the Five Houses

Born in 1956 in the Ibaraki Prefecture in Japan, Sejima formed her own practice in 1987 (Kazuyo Sejima & Associates). While maintaining her own practice, in 1995, Sejima began collaboration with Japanese architect Ryue Nishizawa, forming SANAA (Sejima + Nishizawa and Associates). Sejima, both on her own and in collaboration with Nishizawa, has since designed many award-winning projects including houses, museums, commercial centres and apartment buildings. Sejima's and Nishizawa's work has been exhibited and published in journals and books internationally.

The five houses by Kazuyo Sejima, that are the focus of the current research, were built between 1994 and 2003 in dense, residential areas in Japan. All five houses are designed for families and, as is often the tradition for Japanese families, for up to three generations of the one family. With integral courtyard spaces, which are accessed from most areas of the home, these houses demonstrate Sejima's use of circulation as a design strategy.

Guzman (2007:167) describes Sejima's work as "an architecture defined by visual lightness". These five houses are typical of her small, seemingly transparent houses with thin walls, monochromatic finishes and flat roofs. Luis Fernandez-Galiano (2007: 175) sees these houses as an "architecture in the negative, achieved through a stripping-down" process, her "buildings strive to divest themselves of thickness, dispense with inertia, rid themselves of density."

The Y-House in Katsuura (1994) is a three-storey, flat-roofed structure with two, almost fully glazed, walls and a tall, green marble tiled wall to the street. Sejima designed both the S-House and the M-House in conjunction with Ryue Nishizawa. The S-House (1996) in Okayama, is a small two-storey cubic volume. With an external skin of clear corrugated polycarbonate sheeting on a timber frame, the S-House requires few openings in the facade as it draws light and air through the external skin. The M-House (1997) which is located in Shibuya, utilises a mixture of corrugated metal external cladding and transparent sheeting to suggest the internal space behind the bare walls. Set on a tiny $60m^2$ site, the Small House (2000) is located in Aoyama where it rises from its $34m^2$ footprint in an undulating four-storey volume of steel and glass. Sejima's House In A Plum Grove (2003) has an external skin of steel panels with insulation and gypsum board, and (16mm) structural steel walls internally. With white painted, steel walls, the house is covered on all elevations by thinly framed openings of seemingly random locations and sizes.

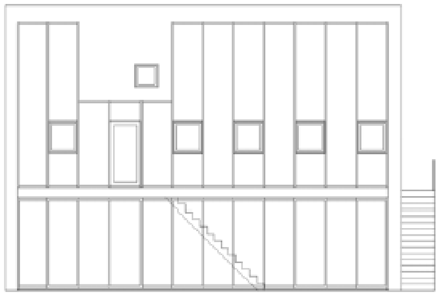


Figure 8: Y-House Elevation 2 D $1.615_{(Archi)}$ and $1.505_{(Benoit)}$

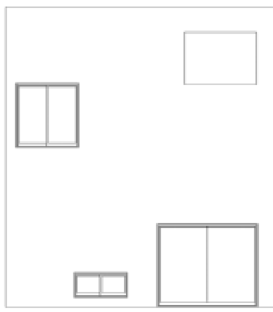


Figure 9: House In A Plum Grove Elevation 3 D $1.297_{(Archi)}$ and $1.247_{(Benoit)}$

Results

The Y-House has a composite *D* result of 1.40875, which is generated from the elevations' average result of $D_{(Elev,\ Archi)} = 1.4605$ and $D_{(Elev,\ Benoit)} = 1.357$. However, the range of individual *D* results for the different elevations for the Y house varies more significantly. For example, Elevation 1 ($1.368_{(Archi)}$ and $1.\ 264_{(Benoit)}$) and Elevation 3 ($1.275_{(Archi)}$ and $1.169_{(Benoit)}$) are quite low results for *D*, while Elevation 2 ($1.615_{(Archi)}$ and $1.505_{(Benoit)}$) (see figure 8) produced the second highest individual elevation result for all of the five houses analysed (see table 2).

Sejima described the S-House as having an "extremely abstract exterior" (Sejima 1999:119); a description which is consistent with the $D_{(comp)}$ value of 1.192125 for the elevations of S House, the lowest result of all of the five houses analysed. The S-House is so stripped of detail, that the South Elevation, which is a minimal, flat wall with one large and small one window shown, has the highest *D* result ($D_{(Archi)} = 1.363$)(see figure 7) for any of the views of the building; higher than the average result of the elevations by $D = 0.11$ or 8.7%.(see table 3).

The M-House results ($D_{(Comp)} = 1.309$) are compromised by the single façade of the house (see figure 10). However, the final composite result is consistent with the rest of Sejima's houses (see table 4).

With the highest composite value, the Small House ($D_{(Comp)}$ =1.450) generally also has the highest individual results for elevations; (1.378< $D_{(Archi)}$ < 1.629 and 1.268< $D_{(Benoit)}$ <1.517) (see figure 6) (see table 5).

With only a 0.001 difference to the $D_{(Comp)}$ result for the S-House, another low composite D value was found in the House In A Plum Grove ($D_{(Comp)}$ =1.193) (see figure 5 & 9). The elevations for this house have consistently low average fractal dimensions (1.150< $D_{(Archi)}$ < 1.297 and 1.074 < $D_{(Benoit)}$ <1.247) (table 6).

The final composite D results for the five houses by Kazuyo Sejima range between the lowest result, for the S-House ($D_{(Comp)}$ = 1.192), and the highest, for the Small House ($D_{(Comp)}$ = 1.450). Overall, the aggregated result for all of Sejima's five houses was $D_{(Agg)}$ = 1.3175 (see table 7).

Table 2: Y-House Data and Results

Views	**IS** (Pix)	**LB** (Pix)	**G** (#)	**D** (Archi)	**D** (Benoit)	**D** (Comp)
Plan	1200x1017	300	13	1.400	1.289	
Elev 1	1200x686	400	14	1.368	1.264	
Elev 2	1200x815	400	14	1.615	1.505	
Elev 3	1200x686	400	14	1.275	1.169	
Elev 4	1200x815	400	14	1.584	1.490	
$D_{(Plan + Elev.)}$				1.4484	1.3434	
$D_{(Elev.)}$				1.4605	1.357	1.4087

Table 3: S-House Data and Results

Views	**IS** (Pix)	**LB** (Pix)	**G** (#)	**D** (Archi)	**D** (Benoit)	**D** (Comp)
Plan	1200x1173	300	13	1.441	1.357	
Elev E	1200x772	400	14	1.151	1.043	
Elev N	1200x786	400	14	1.256	1.113	
Elev S	1200x800	400	14	1.363	1.233	
ElevW	1200x772	400	14	1.248	1.13	
$D_{(Plan + Elev.)}$				1.2918	1.1752	
$D_{(Elev.)}$				1.2545	1.12975	1.1921

Table 4: M-House Data and Results

Views	**IS** (Pix)	**LB** (Pix)	**G** (#)	**D** (Archi)	**D** (Benoit)	**D** (Comp)
Plan	1200 x 686	400	14	1.404	1.254	
Elev S	1200 x 272	75	9	1.361	1.257	
D (Plan + Elev.)				1.3825	1.2555	
D (Elev.)				1.361	1.257	1.309

Table 5: Small House Data and Results

Views	**IS** (Pix)	**LB** (Pix)	**G** (#)	**D** (Archi)	**D** (Benoit)	**D** (Comp)
Plan	1200 x 1200	300	13	1.325	1.252	
Elev 1	688 x 1200	344	13	1.629	1.517	
Elev 2	809 x 1200	405	14	1.378	1.268	
Elev 3	789 x 1200	395	14	1.504	1.401	
Elev 4	789 x 1200	395	14	1.506	1.400	
D (Plan + Elev.)				1.4684	1.3676	
D (Elev.)				1.50425	1.3965	1.4503

Table 6: House in a Plum Grove Data and Results

Views	**IS** (Pix)	**LB** (Pix)	**G** (#)	**D** (Archi)	**D** (Benoit)	**D** (Comp)
Plan	1200 x 1288	300	13	1.349	1.245	
Elev 1	1200 x 1484	317	13	1.221	1.112	
Elev 2	1200 x 1369	263	13	1.150	1.074	
Elev 3	1200 x 1319	278	13	1.297	1.247	
Elev 4	1200 x 1295	283	13	1.244	1.200	
D (Plan + Elev.)				1.2522	1.1756	
D (Elev.)				1.228	1.15825	1.1931

Table 7: Composite and Aggregate Results for Sejima's Houses

House	$D_{(Comp)}$
Y-House	1.4087
S-House	1.1921
M-House	1.3090
Small House	1.4503
House in a Plum Grove	1.1931
$D_{(Agg)}$ for Sejima	1.31064

Conclusion

The results from Sejima's houses match the intuitive response to the elevations implying that the minimalist design lacks a consistent progression of visual detail and that the general range of D results would be in the low range. However, the aggregate results for Sejima were not as consistently low as expected, with the results for Small House and Y House boosting the aggregated results to a higher than expected average.

Ultimately, the approximate fractal dimension of Sejima's architecture is lower than the work of other Twentieth Century architects analysed in previous research. Compared to the Modernist architects Eileen Grey and Le Corbusier, the sample of Kazuyo Sejima's houses (1996-2003) exhibit a slightly lower D result for both individual elevations and for the aggregated result for all of her houses. Compared to the results for five houses (1926-1934) by Gray ($D_{(Agg)} = 1.378$), Sejima's aggregated results ($D_{(Agg)} = 1.3175$) are lower by $D = 0.06$ or approximately 4.4%. In comparison with Le Corbusier's five houses (1922-1928) previously analysed, Sejima's results are lower than Le Corbusier's ($D_{(Agg)} = 1.481$) by $D = 0.16$ or approximately 10.8%.

One explanation for the unexpectedly close result between Sejima and Gray could relate to the fact that three of Gray's houses are unbuilt projects. As noted in a previous examination of Gray (Ostwald and Vaughan 2008), such projects are less developed than completed works and, in Gray's case, have a much lower D result. The close result is also due to the increase in result from Sejima's Small House and Y House, as previously discussed. Thus the gap between these two architects is closer than expected.

One way to investigate this is to consider the clustering of results; the three composite values of each architect that are most closely aligned. In the case of Le Corbusier, there is a tight clustering of $D_{(Comp)}$ values for three of his works (less than 1% difference), and for Gray the clustering result is around 5%, whereas the clustering for Sejima is 8% (see table 8.) If the results are calculated to find an aggregate result for the most closely clustered set of three houses, a more significant result emerges (see table 8). This result suggests that:

1. *Sejima's architecture is much less visually complex than Gray and Le Corbusier.* This supports the standard reading of the method arising from Bovill's work and it is in accordance with qualitative views of these architects' works recorded in architectural histories.
2. *Sejima's architecture may fall into the lowest range of fractal dimensions of architecture.* Sejima's clustered aggregate result is very low, approaching the Euclidean limit of 1.0.

Not many other styles of architecture would fall into this category apart from other strictly minimalist designs, or buildings with predominantly blank walls.

Table 8: Comparison of Results for Sejima, Gray and Le Corbusier

Architect	**Analytical Focus**	**D** (agg)	**Lowest D** (Comp)	**Highest D** (Comp)	**Clustering variation**	**D** (agg) (Clustered best 3 results)
Kazuyo Sejima	5 houses, 1996-2003	1.3175	1.1921	1.4503	0.117 (approx 8%)	1.231
Eileen Gray	5 houses, 1926-1934	1.378	1.289	1.464	0.087 (approx 5%)	1.422
Le Cor-busier	5 houses, 1922-1928	1.481	1.420	1.515	0.015 (<1%)	1.465

The fractal dimension results of these five houses Kazuyo Sejima's may then be applied to the previously discussed findings of a preferred fractal range of approximately $D = 1.3$. According to the results, the M-House would be the most visually pleasing to the onlooker, with $D = 1.3090$. The House in a Plum grove and S-House ($1.1921 < D < 1.1931$), would appear to have their level of visual complexity undesirably low, and the Y-House and Small House ($1.4087 < D < 1.4503$) too high, according to the main body of research on complexity preference.

The information could also be applied to the other previously discussed idea of contextual fit into a particular urban area. Imagine a fractal analysis had been undertaken on a small neighbourhood which found an average fractal dimension of the houses on several streets to be 1.3562. The results from this study would show that the Sejima's design for the Y-House ($D = 1.4087$) or M-House ($D = 1.3090$) would best match the level of visual complexity for the location.

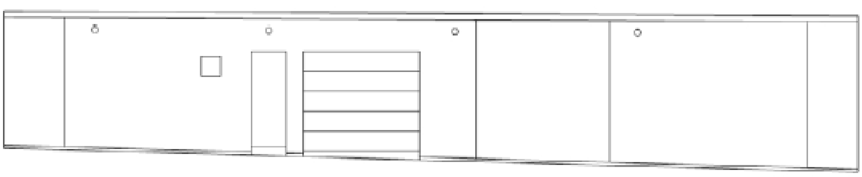


Figure 10: M-House Street Elevation D $1.361_{(Archi)}$ and $1.257_{(Benoit)}$)

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