

# **Evaluating Structural Form: Is it sculpture, architecture or structure?**

## **Abstract**

The purpose of this paper is to discuss the idea of a continuum between sculpture form, architectural form and structural form. A linkage between the various forms will be proposed, and several scholarly views on this subject will be presented. Then, this paper will describe a brief web-based survey which tested people's subjective categorization of various sculptural, architectural and structural forms. The target audience of the web-based survey was college students interested in building design and high school students. Finally, this paper will analyze whether or not presenting the respondents with the idea of a proposed continuum between such forms left a lasting impression on them.

## **A Continuum of Form**

Professor David Billington has proposed that sculptural form, architectural form and structural form are linked in a continuum<sup>1</sup>. All three of these forms are designed, three dimensional structures. Certainly the dividing lines between them can be blurred. Yet there are hallmarks defining each of these three types of form that can be generally agreed upon.

Sculptural form is created by an artist who is interested in exploring aesthetic and formal possibilities in three dimensions. The Swiss architect and Bauhaus artist Max Bill said that the art form of sculpture can be "essentially identifiable as invention...the invention of a means of expression"<sup>2</sup>. Sculptural form can be figurative, for example it can represent some other form. Other sculptures look random, with only the slightest sign that the form was made by an artist. Yet a common denominator in sculptural form is that it is meant to be an aesthetic work, not a functional structure. And it must be three dimensional, and stable and strong enough to carry its own weight.

Architectural form is

dictated by architectural purposes, such as the practicalities of spatial organization and control of the flow of occupants. Architectural form is also concerned with the sense of space a structure creates, its symbolism and its relationship to its setting"<sup>3</sup>.

Certainly architectural form can lean toward sculptural form as in the case where architectural "elements are exaggerated or when forms reflect a nonefficient use of

material just for the sake of emotional impact”<sup>4</sup>. But architectural form is always at least somewhat functional, it is always three dimensional and typically it is client driven. It must satisfy the needs of the client and the occupants, yet it also must satisfy artistic and creative goals of the architect. Finally, it needs to be safe, since it ultimately will be used by people.

Structural form is

dictated by structural needs, primarily to support gravity and lateral loads, and usually also the need to provide a building envelope for shelter against the elements. Carefully designed structural form can exhibit the stark beauty of controlled strength, even to the point of excitement. Structure can define the visual impact of a building, as in the case of large exposed columns which give the appearance of strength and solidity, or the case of tall slender columns which can create an elegant loggia effect.<sup>3</sup>

Structural form is mathematically based, it seeks the greatest efficiency, economy and elegance that the designer can create. It is not random, it is not generated by trial and error, it is not subject to changes in taste or fashion, it is not symbolic of some anthropomorphic idea.

Educator and architect Seymour Howard explored some of the linkages between sculptural form, architectural form and structural form as early as 1966<sup>4</sup>. He derided architectural form that veers toward sculptural form as that whose

dimensions and geometry are chosen, not because of limitations of material, workers’ skills etc. but often in spite of these very limitations.

Structure is made subservient to a design which finds its logic in the architect’s particular aesthetic thought<sup>4</sup>.

Howard labeled such architectural forms as “sculptural structure” and consequently, they would fall somewhere between sculptural form and architectural form on our proposed continuum. The categorization of such a form on a larger continuum is perhaps a more

clear definition of this type of form than Howard's term "sculptural structure". It is such categorizations that we have sought to explore in the web-based survey.

Other writers have more recently criticized this blurring between sculptural form and architectural form. A particularly eloquent if acerbic critique of this blurring came from the British writer and lecturer Charles Jencks who said that such works

typify the case of an architect, not especially trained as an artist, who intends to make a grand sculptural gesture that has never been seen before and yet still make something functional. Caught between opposite requirements, pushed by celebrity culture one way, and pulled by a utilitarian philosophy the other, he may be blind to emergent blooper...function plus unlikely gesture equals a screw-up<sup>5</sup>.

Deyan Sudjic, the architecture critic for the *London Times* recently wrote extensively about the "push by celebrity culture" to shape current architectural forms. He wrote that

architecture has always been dependent on the allocation of precious resources and scarce manpower. As such, its execution has always been at the discretion of those with their hands on the levers of power rather than of architects<sup>6</sup>.

Both Sudjic and Jencks decry the "blatant exhibitionism" of some of the sculptural or pseudo structural forms of contemporary architecture, with particular venom targeted towards Santiago Calatrava who pushes architectural form towards structural form, but in a way that is "stereotyped, produced on the run, quickly built, guaranteed high style, compressed as an image, and of course, inflated in size and self-importance<sup>5</sup>. These comments call to mind the much earlier critique of Howard who said that such "pretentious structure is the label for 'structure for structure's sake' when aesthetic sensitivity is lacking and when novelty of form is the only claim for attention".<sup>4</sup>

The educator and critic Witold Rybczynski also critiqued the failed attempt by clients to make grandiose architectural icons. He exposed France's President Francois Mitterrand's multibillion dollar *Grand Projet* program of national icon building as a failure, as well as Microsoft billionaire Paul Allen's sponsorship of Frank Gehry's Experience Music

Project in Seattle as “confused and confusing, a mishmash of forms, materials and colors that tries too hard to be a literal representation of rock and roll and falls flat”<sup>7</sup>.

The educator and structural engineer Andrew Charleson has written about the juncture between architectural form, which he defines as the “massing or the enveloping form” of a building, with structural form which he understands to be “a building’s primary or most visually dominant structural system.”<sup>8</sup>. He argues that exposing structure in a building can trigger the designer’s imagination and “suggest ways for them to further develop their individual ideas”. This “transformative power of (exposed) structure” can create design opportunities and in fact, be the starting point for overall architectural form.

The distinguished structural engineer Charles Thornton similarly calls for designers to rationally expose structure in their architectural forms, but he goes further and longs for expressed structure, not simply exposed structure<sup>9</sup>. His definition of expressed structure is structural form that can be viewed and understood by an informed observer. Columns that stop short of the ground, ornamental cornices and the like may be exposed structure, but they make no structural sense, thus they do not express any structural ideas.

Such ideas about exposed or expressed structure can be found in many other writers’ works, from the early writings of the French architect and theorist Viollet-le-Duc who argued for Structural Rationalism<sup>10</sup>, through the classic works of the architectural historian Carl Condit<sup>11</sup> who found “architectonic expression” in the rationalism of the Chicago School of architecture. Great structural engineers such as Pier Luigi Nervi and Fazlur Khan have also written on this topic. Nervi said that respecting what is structurally rational and economically prudent actually establishes the “correctness” and the “ethics” of building<sup>12</sup>. Khan argued that

well detailed and efficient structures possess the natural elegance of slenderness and reason, and have possibly a higher value than the whims of a-priori aesthetics imposed by architects who do not know how to work closely with engineers, and who do not have an inner feeling for natural structural forms.<sup>13</sup>

### **What Links the Three Forms Together**

The linkage between these three forms can be summarized as increasing constraints imposed on the designer, as one moves from sculptural form, through architectural form, to structural form. Another way of looking at this linkage is to say that there are

increasing freedoms for the designer as one moves from structural form, through architectural form to sculptural form.

The increasing constraints are varied. There may or may not be a client involved in sculptural form, there is typically no function associated with sculptural form, except for certain kinetic sculptures. The designer is free to make any and all decisions about the form, with virtually the only constraint being that the sculpture must stand on its own.

Architectural form has more constraints imposed on it than does sculptural form. Architectural form typically must satisfy client desires, it must fulfill the spatial, organizational and practical safety issues that are required of architectural structures. Yet it has fewer economic and mathematical constraints on it than does structural form. Especially in today's design world of sophisticated finite element analyses, architectural form has greater latitude, it swings between sculptural form and structural form, with mixed results as evidenced by the aforementioned critiques.

Structural form has the greatest amount of constraints imposed on it, and consequently the least amount of freedom. Structural engineers who create structural form are primarily concerned with safety, economy and constructability of the form. These are quantitative concerns that can be measured and optimized. When a master structural engineer embraces the discipline required of structural form in conjunction with the freedom of personal creativity, then a work of structural art may emerge.

Billington has proposed that the designer of three dimensional form, be it sculptural, architectural or structural, is always concerned with the scientific, the social and the symbolic aspect of the design<sup>1</sup>. The scientific dimension recognizes the need to satisfy the laws of nature, built forms must withstand self weight and applied loads, they must be stable, they must resist weather and the effects of the environment. The social dimension of built form allows for the fact that built forms have a role in the social, the political and the economic climate of our society. The symbolic dimension of built form is concerned with the emotional impact of the form, its visual power and its expressive strength.

By superposing Billington's symbolic, social and scientific dimensions onto the continuum of three dimensional built forms, it becomes clear that that the sculptor is primarily, but not exclusively concerned with the symbolic aspect. The architect's primary, not sole concern, is the social aspect. And the structural engineer's primary criterion is the scientific, but the engineer must also consider the symbolic and social aspect of the built form.

Thus, we see the ever increasing dominance of the scientific aspect corresponds to an increasing set of restraints as we move from sculptural, through architectural to structural form. Yet this does not imply that the structural designer's hands are tied, but it does mean that structural creativity must spring from an ever increasing economic and scientific set of challenges. Designers of architectural and sculptural forms also have these constraints, but they are less severe.

## **A Web-Based Survey Categorizing Form**

The purpose of the web-based survey was two-fold. The first purpose was to see if any trends existed in the responses of architecture students, architectural engineering students, civil engineering students and high school students, as they categorized five different structural forms. The second purpose was to see if the brief introduction of didactic material, as is found on a museum panel for instance, could actually inform the reader of a fairly complicated idea (the continuum of 3D form) in a very succinct manner.

Thus the strategy of the survey was to first have the respondent identify his or her field of study. Then the survey showed five somewhat similar images. We decided to use only non-habitable tall slender towers as our forms. The reasoning was that we needed to control variability as much as possible and not introduce a wide range of structures. After viewing the five forms, the respondent was asked to categorize them as sculptural, architectural or structural form, but to do so without any guidance or prompting from the survey. Then, a brief educational panel of material presented the previously described continuum of three dimensional forms and the linkage of increasing constraints. After this presentation, the respondent was asked to once again categorize the forms. It is this second categorization that we used in our data analysis. The reason for using the second ranking was that we assumed it would be a more thoughtful categorization than the first.

Designing such a survey is fraught with challenges. It was quickly discovered that it is very difficult to not present “loaded” questions, i.e. questions that lead the respondent in one direction or another. The choice of forms was challenging, what to choose, how many to use? Certainly one could argue endlessly about the choice of forms, was one too obvious, was one too vague in its “location” on the continuum of three dimensional forms? Practical issues of the design of the web interface, permission for images, publicizing the survey, encouraging students to actually fill it out, all these issues took some time to master. And ultimately, we understood that this is an entirely subjective survey, there really are no correct answers!

The chosen five towers merit some explanation. All were tall, slender, non-habitable towers. All had some features that could reasonably merit categorization in more than one slot. The purpose of this was to not make the choices too easy, but in retrospect, perhaps the choices were too difficult because there are no clear outliers. An attempt was made to avoid extremely well known towers, the Eiffel Tower for example. Tower #1 is a 30 m tall hyperbolic paraboloid thin shell concrete water tower. It was built in 1965 in Moglingen Germany, with architectural design by R. Kessler and structural engineering design by F. Cenek. Tower #2 is a 118 m tall observation tower known as Euromast. It was built in 1960 in Rotterdam, Netherlands and the architectural design was done by J. Maaskant, with structural engineering design done by A. J. Neste and R. Swart. Tower#3 is a ?? m tall, masonry water tower, designed by the Uruguayan structural engineer Eladio Dieste in ???. It is located in ???, Uruguay. Tower#4 is a 29 m cast iron sculpture

designed by the famous sculptor Constantin Brancusi. It was built in 1938 in Târgu Jiu, Romania. Tower#5 has yet to be built. It is known as the “Shanghai Kiss”, designed by British Architect William Alsop, with structural engineering done by London’s Arup office. It is to be a 250 m tall observation tower, designed to attract visitors to the World Expo 2010.

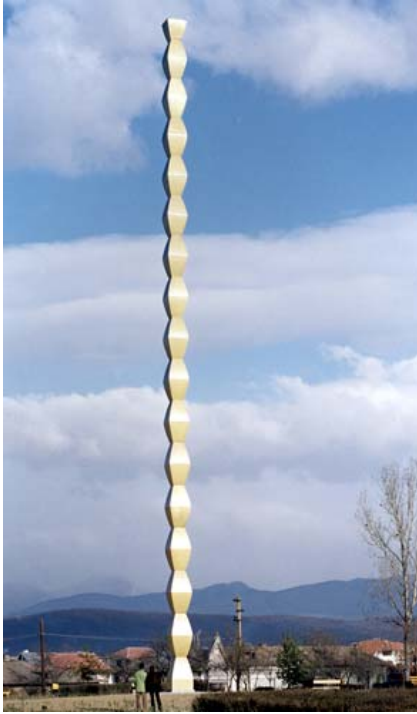
Thus, although one structure is solely the work of a sculptor (Brancusi’s Tower#4), and one is solely the work of an engineer (Dieste’s Tower#3), all of the forms have sculptural, architectural and structural features.

The following is the survey which nearly one thousand respondents filled out.

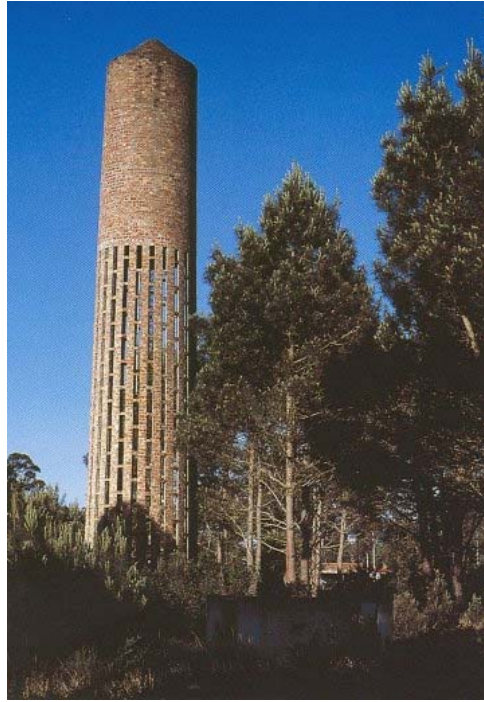
**1. Please tell us who you are?**

- Architecture Student
- Architectural Engineering Student
- Civil Engineering Student
- High School Student
- Architecture Faculty
- Engineering Faculty
- Other (please specify)

Please look at the five towers on the following page. You will be asked to rank them according to a single criterion.



Tower #1



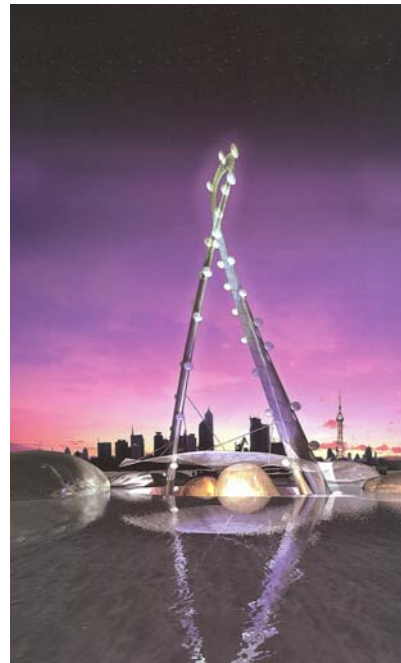
Tower #2



Tower #3



Tower #4



Tower #5



Please rank these 1 to 5, with 1 being the most sculptural and 5 being the most structural

	1	2	3	4	5
	<i>Sculptural</i>		<i>Architectural</i>		<i>Structural</i>
<b>Tower #1</b>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<b>Tower #2</b>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<b>Tower #3</b>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<b>Tower #4</b>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<b>Tower #5</b>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

### The Text Panel

Sculptors, architects and structural engineers are all concerned with designing three dimensional forms. Yet, they create their forms according to different criteria.

Sculptors often create their sculptures before they have a client. Thus, they are free to create what appeals to them aesthetically. They always consider their creations to be works of art, and the sculpture may or may not be purchased after it is completed. If the sculpture is large, issues of structural safety and integrity must be addressed by the sculptor.

Architects design numerous forms, only some of which actually get built. For an architectural design to come to fruition, it must satisfy the client's needs as well as local building codes to ensure safety of the public. Architects work with many different people to realize their vision of a completed form. Some of these people include structural engineers, construction managers, the client, government officials and citizen review boards.

Structural engineers design many types of forms, some of which are dictated by architectural concerns such as office buildings and sports arenas. Other forms have no architectural designers, they are utilitarian and they are designed to perform their prescribed function, at a minimal cost and optimum safety levels. These may be storage tanks, chimneys, electrical utility towers and the like. Yet some structural engineers are able to combine practical utility with aesthetically pleasing forms.

**3. Do you think that sculptural form has more freedom or less freedom than architectural form?**

More freedom

Less freedom

It depends!



**4. Do you think that architectural form has more freedom or less freedom than structural form.**

More freedom

Less freedom

It depends!



Please look at the towers again and rank them once again, from most sculptural to most structural.

*(Here, the same five images were shown once again in their original order)*

Please rank these 1 to 5, with 1 being the most sculptural and 5 being the most structural

	1	2	3	4	5
	<i>Sculptural</i>		<i>Architectural</i>		<i>Structural</i>
<b>Tower #1</b>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<b>Tower #2</b>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<b>Tower #3</b>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<b>Tower #4</b>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<b>Tower #5</b>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

## Results Of The Survey

Nearly one thousand people took this survey. The following tables and figures summarize their responses of all participants. Further breakdown according to area of study will be shown later.

1. Please tell us who you are?			
		Response Percent	Response Total
Architecture Student		42.4%	412
Architectural Engineering Student		32%	311
Civil Engineering Student		10.8%	105
High School Student		6.2%	60
Architecture Faculty		1.8%	17
Engineering Faculty		2.1%	20
Other (please specify)		4.7%	46
<b>Total Respondents</b>			<b>971</b>
(skipped this question)			0

2. Rank the towers from the most sculptural (left hand side) , to the most structural (right hand side). Multiple towers can have the same ranking.						
	Sculptural	<----->	Architectural	<----->	Structural	Response Total
Tower #1	4% (35)	19% (167)	35% (302)	27% (232)	15% (125)	861
Tower #2	2% (15)	8% (72)	25% (219)	36% (310)	28% (243)	859
Tower #3	2% (16)	8% (69)	27% (231)	37% (315)	27% (228)	859
Tower #4	37% (322)	38% (329)	14% (117)	6% (53)	5% (39)	860
Tower #5	66% (566)	16% (140)	9% (77)	5% (39)	5% (39)	861
<b>Total Respondents</b>						<b>861</b>
(skipped this question)						110

*(Note, the text panel describing the three forms came at this point in the survey)*

3. Do you think that sculptural form has more freedom or less freedom than architectural form?			
		Response Percent	Response Total
More freedom		81.6%	645
Less freedom		8%	63
It depends!		10.4%	82
<b>Total Respondents</b>			<b>790</b>
(skipped this question)			182

4. Do you think that architectural form has more freedom or less freedom than structural form.			
		Response Percent	Response Total
More freedom		62.8%	495
Less freedom		21.7%	171
It depends!		16.8%	132
<b>Total Respondents</b>			<b>788</b>
(skipped this question)			183

Then the respondents were asked to ONCE AGAIN categorize the forms. It is this second categorization that we will analyze in the results section, with the idea that this might exhibit less scatter than the first categorization.

5. Rank the towers from the most sculptural (left hand side) , to the most structural (right hand side). Multiple towers can have the same ranking.						
	Sculptural	<----->	Architectural	<----->	Structural	Response Total
Tower #1	4% (30)	17% (131)	<b>40% (303)</b>	26% (200)	12% (91)	755
Tower #2	2% (18)	8% (57)	26% (194)	32% (242)	<b>32% (243)</b>	754
Tower #3	2% (14)	7% (54)	28% (211)	<b>39% (291)</b>	24% (183)	753
Tower #4	<b>41% (309)</b>	36% (275)	13% (99)	5% (37)	5% (35)	755
Tower #5	<b>63% (476)</b>	17% (132)	10% (79)	5% (36)	4% (33)	756
<b>Total Respondents</b>						<b>756</b>
(skipped this question)						215

6. If you'd like to leave some comments, please do so now.	
<b>Total Respondents</b>	77
(skipped this question)	894

## Analysis of Answers

### ALL RESPONDENTS

When viewing the entire group of respondents, there was fairly clear consensus on how to categorize each tower. Tower#1, the concrete water tower, was chosen by 40% of the respondents as an architectural form, with another 26% placing it between architectural and structural. Only 4% labeled it as sculptural.

Tower#2, the Euromast, was placed by 32% as structural, another 32% as being between structural and architectural, and 26% as architectural. Very few (10%) placed it towards the sculptural end of the continuum.

The Dieste water tower, Tower #3, was very similarly categorized. Almost all respondents (91%) placed it between somewhere on the architectural/structural side of the continuum.

Brancusi's Endless Column sculpture was "correctly" placed by 41% as sculptural and another 36% between sculptural and architectural. Very few (5%) categorized it as structural. Perhaps this is because it may have been recognized by the respondents, seeing as it is the most famous of the five towers.






Alsop's observation tower The Shanghai Kiss, was categorized by 63% as purely sculptural. One explanation for the avoidance of the architectural category may be that the image is from fairly far away, and one cannot readily see that this is an observation tower.

The answers to the "more or less" freedom had an overwhelming favorite. 82% of the respondents agreed that sculptural form has more freedom than architectural form. This corresponds to the point of the didactic text panel.

Similarly, 63% agreed that architectural form has more freedom than structural form. Curiously, 22% disagreed. This is counter to the "advice" of the didactic panel. There may be two explanations for this. One is that the respondents understood the panel, but simply disagreed with its premise. The other explanation is that they did not understand the panel.







## Analysis of Answers ARCHITECTURE STUDENTS ONLY

Moving on to the filtered responses, we first look at the largest group, the Architecture Students only, who made up 42% of the total responses.

6. Five Forms once again						
5. Rank the towers from the most sculptural (left hand side) , to the most structural (right hand side). Multiple towers can have the same ranking.						
	Sculptural	<----->	Architectural	<----->	Structural	Response Total
 Tower #1	4% (14)	20% (62)	<b>40% (125)</b>	26% (81)	10% (33)	<b>315</b>
 Tower #2	2% (6)	6% (20)	28% (89)	<b>34% (106)</b>	30% (94)	<b>315</b>
 Tower #3	1% (4)	7% (22)	27% (85)	<b>42% (132)</b>	23% (71)	<b>314</b>
 Tower #4	<b>39% (123)</b>	36% (112)	14% (44)	4% (14)	7% (22)	<b>315</b>
 Tower #5	<b>60% (191)</b>	18% (57)	12% (38)	6% (18)	4% (12)	<b>316</b>
<b>Total Respondents</b>						<b>316</b>
(filtered out)						440
(skipped this question)						216






These results are virtually identical to the total group's response, no statistical significance was found in minute differences from overall group's responses.

When it came to the questions about freedom, the first answer (Sculptural form vs. Architectural form) was extremely similar to the overall group response. But the question about freedom in Architectural form vs. Structural form, found slightly less unanimity than before, with the "It depends" category gathering 21% now as opposed to 17% for the total group.

5. Constraints			
3. Do you think that sculptural form has more freedom or less freedom than architectural form?			
		Response Percent	Response Total
More freedom		<b>79.7%</b>	<b>263</b>
Less freedom		5.8%	19
It depends!		14.5%	48
<b>Total Respondents</b>			<b>330</b>
(filtered out)			459
(skipped this question)			183
4. Do you think that architectural form has more freedom or less freedom than structural form.			
		Response Percent	Response Total
More freedom		<b>59.9%</b>	<b>197</b>
Less freedom		20.4%	67
It depends!		21.3%	70
<b>Total Respondents</b>			<b>329</b>
(filtered out)			459
(skipped this question)			184

## Analysis of Answers ARCHITECTURAL ENGINEERING STUDENTS ONLY

The next filtered response we look at is the second largest group, the Architectural Engineering Students only, who made up 32% of the total responses. Their categorization was as follows.

6. Five Forms once again						
5. Rank the towers from the most sculptural (left hand side) , to the most structural (right hand side). Multiple towers can have the same ranking.						
	Sculptural	<----->	Architectural	<----->	Structural	Response Total
 Tower #1	2% (6)	16% (39)	<b>41% (101)</b>	29% (72)	12% (31)	<b>249</b>
 Tower #2	1% (3)	9% (23)	24% (59)	31% (76)	<b>35% (87)</b>	<b>248</b>
 Tower #3	1% (2)	6% (15)	30% (74)	<b>37% (91)</b>	27% (67)	<b>249</b>
 Tower #4	<b>40% (100)</b>	37% (93)	14% (35)	5% (13)	3% (8)	<b>249</b>
 Tower #5	<b>62% (154)</b>	20% (49)	8% (20)	6% (15)	4% (11)	<b>249</b>
<b>Total Respondents</b>						<b>249</b>
(filtered out)						507
(skipped this question)						216

There was no statistical significance to the small variations in categorizations of forms by the Architectural Engineering students compared to the overall group and compared to the Architecture students.

The Architectural Engineering students answered the questions about freedom as follows.






5. Constraints			
3. Do you think that sculptural form has more freedom or less freedom than architectural form?			
		Response Percent	Response Total
More freedom		84.7%	221
Less freedom		8%	21
<input type="button" value="View"/> It depends!		7.3%	19
<b>Total Respondents</b>			<b>261</b>
(filtered out)			528
(skipped this question)			183
4. Do you think that architectural form has more freedom or less freedom than structural form.			
		Response Percent	Response Total
More freedom		71.5%	186
Less freedom		17.3%	45
<input type="button" value="View"/> It depends!		12.7%	33
<b>Total Respondents</b>			<b>260</b>
(filtered out)			528
(skipped this question)			184

The Architectural Engineering students slightly more unanimously on the question of sculptural form having more freedom than architectural form (ARCE 85% vs. 82% for

the entire group and 80% for Architecture). But on the question of freedom of architectural form versus structural form, the Architectural Engineering students had significantly more unanimity than both the overall group and the Architecture students (72% ARCE versus 63% for the entire group and 60% for the Architecture students). A reason for this may be that the Architectural Engineering students are naturally more aware of and interested in structural form, and they are particularly attuned to the difference between structural design and architectural design.

## Analysis of Answers CIVIL ENGINEERING STUDENTS ONLY

The next filtered response we look at is the third largest group, the Civil Engineering Students only, who made up 11% of the total responses. Their categorization was as follows.

6. Five Forms once again						
5. Rank the towers from the most sculptural (left hand side) , to the most structural (right hand side). Multiple towers can have the same ranking.						
	Sculptural	<----->	Architectural	<----->	Structural	Response Total
 Tower #1	2% (2)	20% (17)	42% (36)	26% (22)	9% (8)	85
 Tower #2	0% (0)	4% (3)	21% (18)	39% (33)	36% (31)	85
 Tower #3	1% (1)	5% (4)	21% (18)	42% (35)	31% (26)	84
 Tower #4	42% (36)	38% (32)	15% (13)	4% (3)	1% (1)	85
 Tower #5	72% (61)	15% (13)	11% (9)	0% (0)	2% (2)	85
					<b>Total Respondents</b>	<b>85</b>
					(filtered out)	671
					(skipped this question)	216

The categorizations of the Civil Engineering students generally agreed with the other groups' categorizations, with only slight variations in some of the answers. For example, the Civil Engineering students had slightly less scatter with Tower#5, Alsop's Shanghai Kiss, tending to group it solidly in the sculpture category with a 72% vote there (the other groups had 63% and 60% for Tower#5 as sculpture). This difference was not large enough to merit further investigation.

With regard to the question on freedom, the Civil Engineering students voted nearly the same as the overall group on the first question. And as with did Architectural Engineering students, the Civil Students had more unanimity on the question about structural form versus architectural form than did the Architecture students. 73% of Civils said architectural form has more freedom than structural form, compared to 63% for the entire group, 60% for Architecture students and 72% for ARCEs).



3. Do you think that sculptural form has more freedom or less freedom than architectural form?			
		Response Percent	Response Total
More freedom		81.8%	72
Less freedom		13.6%	12
<a href="#">View</a>	It depends!	4.5%	4
		<b>Total Respondents</b>	<b>88</b>
		(filtered out)	781
		(skipped this question)	183

4. Do you think that architectural form has more freedom or less freedom than structural form.			
		Response Percent	Response Total
More freedom		72.7%	64
Less freedom		18.2%	16
<a href="#">View</a>	It depends!	9.1%	8
		<b>Total Respondents</b>	<b>88</b>
		(filtered out)	780
		(skipped this question)	184

## Analysis of Answers HIGH SCHOOL STUDENTS ONLY

The last filtered response we look at is the fourth largest group, the High School Students who made up only 6% of the total responses. While this is a small group, it is still interesting to look at their responses, with the caveat that it is not a large data set.

6. Five Forms once again							
5. Rank the towers from the most sculptural (left hand side) , to the most structural (right hand side). Multiple towers can have the same ranking.							
	Sculptural	<----->	Architectural	<----->	Structural	Response Total	
 Tower #1	13% (6)	21% (10)	28% (13)	28% (13)	11% (5)	47	
 Tower #2	19% (9)	13% (6)	21% (10)	19% (9)	28% (13)	47	
 Tower #3	15% (7)	17% (8)	34% (16)	9% (4)	26% (12)	47	
 Tower #4	49% (23)	30% (14)	9% (4)	9% (4)	4% (2)	47	
 Tower #5	66% (31)	9% (4)	13% (6)	0% (0)	13% (6)	47	
						<b>Total Respondents</b>	<b>47</b>
						(filtered out)	789
						(skipped this question)	216

Although it is dangerous to draw too many conclusions from this smallest set, one difference in categorizations is immediately evident. The High School students had greater unanimity in the placement of the Brancusi sculpture (Tower#4) in the category of Sculptural form. This “correct” answer was detected most by the High School students with 49%! The other categorizations show no large variations from the overall group.

The second question on freedom was answered differently by the high school students, than by the overall group. The high school students disagreed with the overall group and with the other sub groups on the question of freedoms between architectural form and structural form. They voted that architectural form actually has less freedom than structural form, whereas the others answered the question “correctly” in accordance with the didactic text panel. Perhaps the high school students did not understand the brief panel presenting the concept of restraints and freedom.

3. Do you think that sculptural form has more freedom or less freedom than architectural form?			
		Response Percent	Response Total
More freedom		78.7%	37
Less freedom		19.1%	9
<a href="#">View</a> It depends!		2.1%	1
		<b>Total Respondents</b>	<b>47</b>
		(filtered out)	742
		(skipped this question)	183

4. Do you think that architectural form has more freedom or less freedom than structural form.			
		Response Percent	Response Total
More freedom		38.3%	18
Less freedom		57.4%	27
<a href="#">View</a> It depends!		6.4%	3
		<b>Total Respondents</b>	<b>47</b>
		(filtered out)	741
		(skipped this question)	184

## Conclusions

When faced with a clear continuum of forms, from sculptural through architectural to structural, students tended to categorize forms consistently. Whether the student was studying architecture, architectural engineering, civil engineering, or was in high school, the categorizations were generally the same.

We argue that this continuum of form is helpful when discussing three dimensional designs. Furthermore, the common thread of increasing scientific concerns imposed on the designer, as one moves from sculptural form, through architectural form to structural form, is helpful to those who want to discuss and critique large three dimensional forms.