BRITNEY AND K-FED: THE UNION OF PROCESSED AND UN-PROCESSED COMPONENTS IN AFFORDABLE HOUSING

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> At a September 18, 2004 ceremony in Studio City, Calif., *newlyweds Britney Spears and Kevin Federline (K-Fed) were acting like blissed-out newlyweds: gazing into each other's eyes. Locking bare toes. Exchanging "Oh babys" and "I love yous." 40 hours later, lounging with her new husband near the hot tub in the presidential suite of the Hotel Bel-Air Spears said she felt, "Awesome. Elated." Tying the knot "couldn't have been better," says Federline. Adds Spears: "I'm just kind of happy that we pulled off the whole thing."*[1]

Although the marriage did not last any longer than two years, and its significance in pop-culture is all but forgotten, the union remains representative of a form of potential. As Christian Hoard of Rolling Stone Magazine observed in 2007, *"the marriage (of Britney and K-FED) melds a finely processed product with something raw and indeterminate."* Hoard continued by projecting into the future with reasoned confidence, *"we can only hope that the resulting aesthetic is less plastic and more appealing - without being too revealing."*[2] The reported bliss of September 18, 2004 did not last long enough for anyone to determine if Hoard's would maintain any veracity. That is as inconsequential as the marriage proved to be; it is the potential embedded in Hoard's assessment of the action that suggests something of consequence - that there might not only be economic benefit, but also artistic integrity in the union of the *"raw and indeterminate"* with the *"finely processed product."*

As Britney and K-Fed were sifting through what remained of their previous elation, the coarse characterizations of their public personas were influencing the development of an affordable housing prototype in Tucson, Arizona. Constructed from a union between mechanically precise pre-fabricated components and raw indeterminate components modified at site, techniques employed in the realization of the ARMADILLO RESIDENCE (DDBC RESIDENCE III) emerged as a strategic proposition for the creation of place specific architecture crafted in the context of limited economic investment and tight time constraints.

Primarily constituted of linear prismatic light guage steel members delivered to site in compact process packed bundles, the prototype illustrates potential advantages in the broader discourse on pre-fabrication of affordable single family residences: 1) Eliminating the impact of projected overhead expense in warehousing a construction site/production line; 2) Eliminating redundancies in regulatory oversight; 3) Eliminating transportation systems (dimensional road and rail constratints) as the determinant filter in manifesting architectural/formal response to place; 4) Reducing the negative impact of inefficiencies that escalate transportation costs in the transfer of modular and unitized construction; 5) Creating a non-investment intensive, localized, skill focused job development mechanism, and; 6) Maintaining the hand and the scale of the human as a determinant factor on the construction site – and in the resulting architecture. (Figure 1) These factors emerged as a by-product, and are in service to the primary need-based social aspirations of the architectural proposition. Pre-fabrication, and the form of pre-fabrication utilized in the realization of the ARMADILLO RESIDENCE were elected to serve those aspirations, not as devices in and of themselves.

DEVELOPMENT CONTEXT PARAMETERS

The ARMADILLO RESIDENCE (DDBC RESIDENCE THREE) is 1,198 SF sustainable affordable housing prototype intended for families with an annual income level falling below the sixty percent median household income level in the Tucson, Arizona metropolitan region. It is the third of five prototypes developed by the Drachman Design Build Coalition (DDBC), a non-profit 501c3 corporation affiliated with the University of Arizona College of Architecture and Landscape Architecture. The DDBC offers faculty and student technical expertise to the local community in Southern Arizona with the expressed mission of developing and disseminating replicable, regionally specific, energy efficient design and construction strategies to a broad audience. The design of the residence was completed as part of the Civano Demonstration Project Grant, a two hundred and thirty-four thousand dollar grant awarded to the DDBC by the City of Tucson. Development and construction costs were funded through a line of credit provided by the Industrial Development Authority (IDA) of Tucson.

The house is sited in Tucson's Barrio San Antonio Neighborhood, on a vacant 0.71-acre industrial parcel of land located just west of Tucson's Central Business District. The site is bounded by sparsely populated residential blocks to the North and East with a regional transportation artery, Aviation Highway, forming the southern and western boundaries. The City of Tucson Community Services Agency deeded the parcel to the DDBC in March of 2007. Following the transaction, the DDBC initiated a year long rezoning and subdivision process that resulted in site reclassification from industrial to

Figure 1. View of the completed ARMADILLO RESIDENCE Structural Frame. Constructed in under 12 hours, the frame, lateral, and vertical trusses are pre-fabricated components flat packed and shipped to site.

residential use. As a condition of the rezoning the vacant parcel was subdivided into five lots matching common infill lot sizes in Tucson's Empowerment Zone.

The intention behind developing the deeded parcel in this manner was to develop five housing prototypes, illustrating the benefits of higher density development. Grant funding provided for re-zoning, parcel realignments, and design of the structures came with governing stipulations identifying performance benchmarks were to be demonstrated in urban development. The most significant objective required the reduction of open land to 35% of the toatal developed footprint; a substantial reduction for traditional development in Tucson. Other objectives included reductions in potable water consumption by 65%, reductions in landfill destined solid waste by 50%, and reductions in internal neighborhood vehical miles by 40%. These benchmarks are representative of desired changes in urban development strategy being legislated in Southern Arizona, but they represent only a portion of the overall objectives with regard to sustainability.

Families elegible to live in the ARMADILLO RESIDENCE had to be fully employed and were required to complete a HUD approved Homeowner Education Program (HEP). The program taught potential residents about mortgages, interest, insurance, budgets, and equity. All family members had to demonstrate a record of positive citizenship with no felony convictions. And, the families had to qualify for a 30 year mortgage at the prevailing interest rate, having saved $1,500.00 for their own down payment. The mortgage payments plus utilities could not exceed 30% of the gross monthly income. In 2008, the median income in Tucson Arizona for a family of four was $41,000.00. At that income level, the total dollar value available for mortgage, insurance, taxes, and utilities was $1,025.00 per month. With this criteria, the house principal and interest payment needed to remain below $700.00 per month, with monthly utility bills being held below a rate of $80.00 per month. These parameters demanded that both the initial investment costs and monthly opertional cost remain low. For the latter to be satisfied, the house needed to be site specific and environmentally responsive.

Adjusting Terrain

The ARMADILLO RESIDENCE occupies a 50' wide by 125' long lot on the Civano Demonstration Project Site. The lot is challenged with regard to solar orientation, maintaining a primary North/South cardinal orientation. Consistent with all lots on the Civano Demonstration Project Site, the masterplan incorporates strategies to maintain water on site through the use of xeriscape microbasins and 100% rainwater collection from roofs and hardscape features in, and surrounding, the site. That level of continuity was instrumental in considering the terrain as a unified landscape rather than a collection of individula lots. The lots and building pads were calibrated to harmonize with the developed microclimate, enhancing the sustainability of each individual residence.

SPACE, ORGANZATION, AND FORM

The spatial organization of the ARMADILLO RESIDENCE is a generative response to both the severe environmental conditions of the Sonoran Desert and the adjusted microclimate of the site. To mitigate the challenges presented by the predominant North/South axial orientation, a spatial strategy was developed to manage the intense solar conditions on the eastern and western exposures. A pair of shaded courtyards were established, one on the east side of the house and another on the west; enabling the dwelling to wrap around and shade itself from the sun. (Figure 2) The courts are positioned relative to one another and the enclosed building mass in a manner that induces positive airflow for maximum passive ventilation. The prevailing winds from the southeast and southwest are channeled from the south façade of the residence through the primary circulation corridor.

Ventilation apertures off of the courtyards introduce cool air into the corridor which propels the mixed air through the primary living area and out of a small aperture located near the top of the north façade. A twelve-foot long operable panel located in the primary passive ventilation corridor enables the development of spatial continuity between independently identifiable zones that traditionally

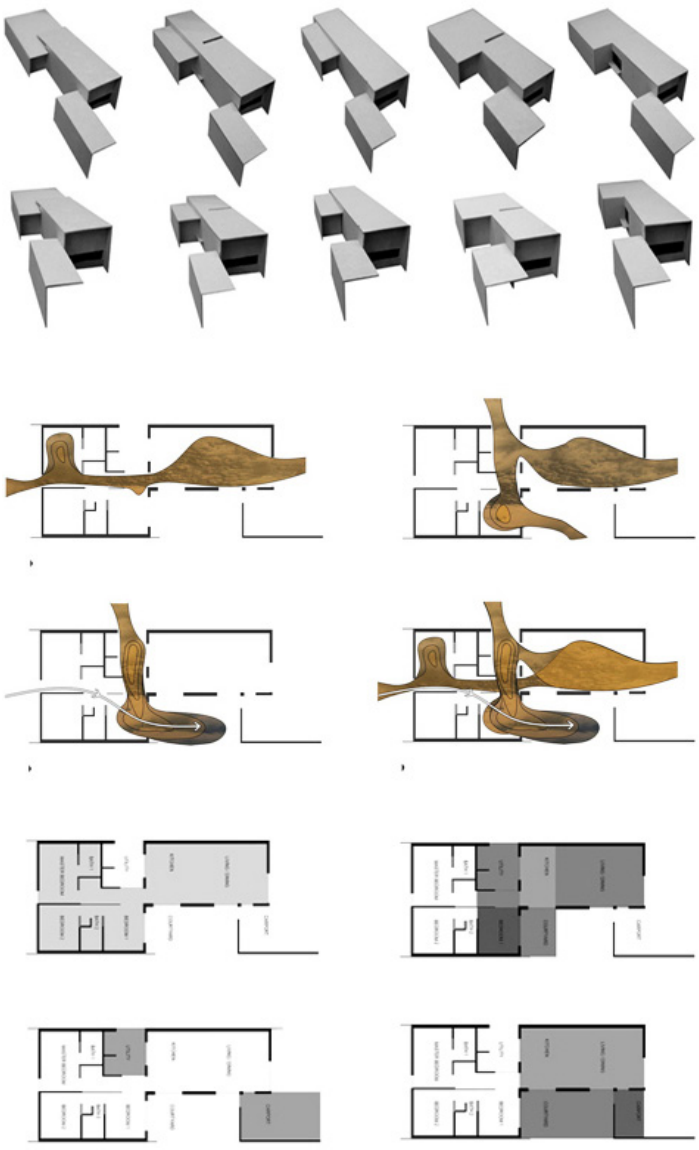

Figure 2. Top: Massing models illustrating the formal/volumetric configuration of the building with nuanced planar variations; Middle: Diagrams illustrating the passive ventilation strategies with different spatial configurations; Bottom: Diagrams illustrating spatial variations enabled.

remain static/segregated in affordable housing prototypes. The flexibility provided by the moving partition and offset courtyards enable multi-generational families to configure the house in a manner that best suits their working and living behavior. It further reinforces the ability to engage larger portions of habitable area that extend to the urban context – retracing vernacular traditions.

The formal strategies employed in the house are a direct reflection the environmental condition. A long sloping insulative shell constructed of light guage steel framing and profile metal panel protects the interior spaces from the harshest exposures on the site – the east, south, west, and roof exposures. On the northern and southern exposures, where air and light are are chanelled, a ventilated fiber cement panel screen walls are employed to mitigate residual heat gain and re-radiated energy. It is through those walls that all primary apertures through the enclosure system are invested. Apertures are eliminated on the east and west exposures unless the mass of the building or vegetation provides appropriate shading. The slope of the roof and expansion of the spatial geometry from south to north enhances passive air flow, drawing cooled air in from the flanking courts.

MATERIAL AND STRUCTURE

Decisions Regarding material and structure were made in reference to five criteria: 1) Support of Place Specific Design Strategies, 2) Durability, 3) Initial Investment Economics, 4) Life Cycle Economics, and 5) Localized Job Creation. After exploring a number of materials and systems, light guage steel presented itself as an appropriate vehicle for exploration. As has been widely promoted by the Steel Stud Manufacturer's Association (SSMA) since the early 1990's, light guage steel framing offers numerous advantages that can prove to be sympathetic with the five criteria outlined above. The positive attributes consistently articulated by SSMA members include:[3]

1. On Average, Steel Components weigh 60% less than wood. A 2000SF home requires only 6 tons of steel vs. 20 tons of lumber.
2. Steel Construction Components can be pre-measured and pre-cut to exact specifications. On site adjustments are generally not required.
3. Steel remains straight and true in transport, woood warps and cracks.
4. Because Steel is noncombustible and termite proof, It qualifies for what insurance companies reference as "superior construction" and insurance premiums are traditionally lower.
5. The quantity of waste on a residential construction site is 2% with light guage steel framing vs 20% with wood framing.
6. All light guage steel components are 100% recyclable.

Depending on the SSMA source providing information, the list of attributes, when addressing nuances, can be extensive. But, just considering the six points refrenced, the decision to utilize light guage steel framing appears obvious: 1) it fulfills a desire to maximize durability; 2) enhances both speed and accuracy in construction, and; 3) by virtue of the first two points promises to reduce both life cycle and initial investment costs. The local construction environment in Tucson could be viewed as a challenge or an opportunity. Light Guage Steel Framing is anathema in Southwestern, Arizona. The predominance of Carpenter's Unions and allied training programs coupled with a limited presence of the Steel Framing Alliance (SFA) and Light Guage Steel Engineers Association (LGSEA) have meant that the bias in Arizona's residential construction market has favored woood frame construction almost exclusively. With only one representative of the Steel Stud Manufacturer's Association (SSMA) maintaining a presence in the region, proper investment in training has not been made to overcome negative biases regarding light guage steel framing.

Historically, steel has been more expensive to construct with than wood framing. But, that is only the case if light guage steel framing is employed as a replacement for wood stick framing on a one to one basis - where each stick of lumber utilized in a platform or baloon framed house is replaced with a similarly sized piece of light guage steel framing. With the predictability of behavior that the material possesses, development of Building Information Modelling (BIM), and use of Parametric Analysis, there is no reason to employ light guage steel in redundant arrays that violate the nature of the material. The development of the ARMADILLO RESIDENCE was informed by advanced digital simulation and employs a structural framing strategy that is predicated on steels properties and prediliction toward advantages in pre-fabrication.

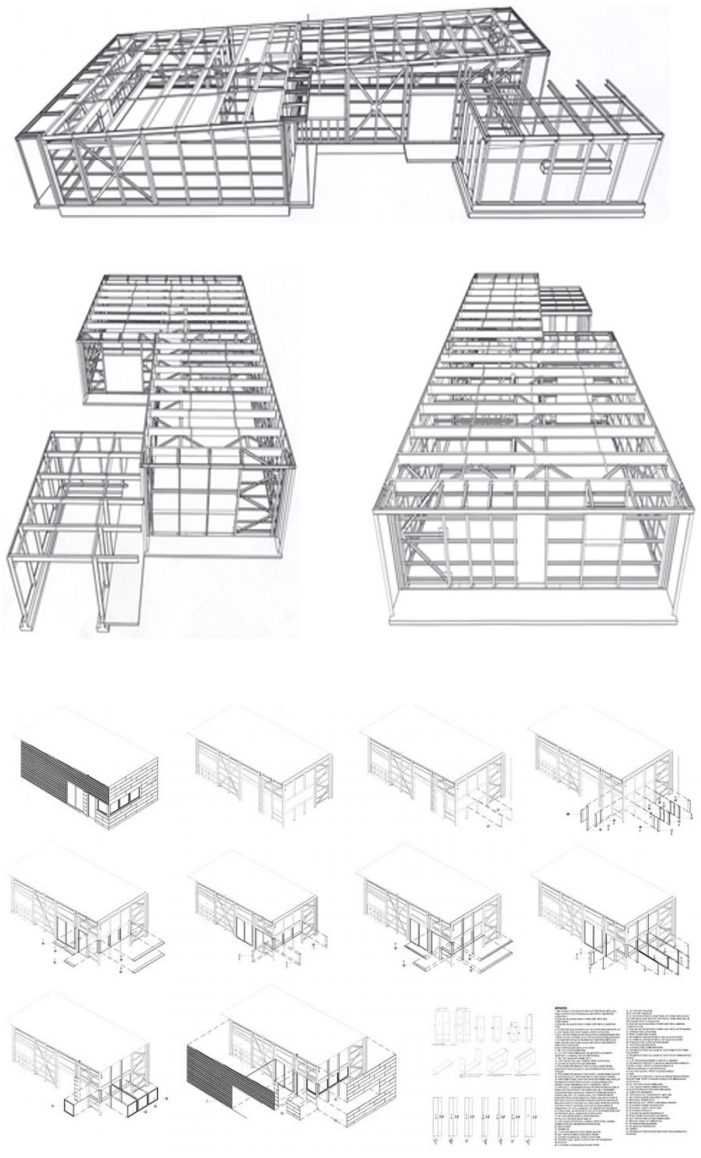

Figure 3. Top: Views of the Primary Pre-Fabricated Frame Structure developed in STAAD.pro and REVIT; Bottom: Construction Documents executed in REVIT and AutoCAD illustrating the integration of secondary and tertiary elements with the pre-fabricated frame.

BRITNEY

Traditionally, light guage steel framing has been employed in planar assemblies, mimicking constructive techniques that are appropriate with dimensional lumber where redundancy is necessary.[4] If analyzed in isolation, light guage steel framing elements of significant enough material thickness and/or pre-disposed geometric form can be employed more efficiently as columns and beams. Analyais completed utilizing STAAD.pro demonstrated that the ARMADILLO RESIDENCE could be constructed utilizing a series of pre-fabricated light guage steel columns and beams placed on 4'-0" centers (Figure 3).

BIM Softawre (REVIT) was utilized simultaneous with the STAAD.pro analysis as a mechanism to determine what advantages and disadvantages would be yielded in the development of assemblies and construction sequencing. After a comprehensive review of all constructive systems, the alternative framing strategy was elected. Each light guage steel column and beam was pre-cut, pre-drilled, and scored for alignment utilizing digital fabrication equipment at the Steeler Inc plant outside Seattle, Washington. Because of the structure's site specific/variable geometry, 70% of the components produced were unique, the other 30% were produced in pairs. All digital files for the production of the components were provided to Steeler Inc by the DDBC. AutoCAD and Mastercam were the digital interface mechanisms for that production.

These components were delivered to site in a flat pack, numbered and stacked in the order that they would be placed into the foundation anchoring system on site. The columns were pre-fabricated from 10 guage steel and the beams from 14 guage steel or 16 guage steel, depending on the span and location of the member. The columns and beams were braced laterally by a series of pre-fabricated light gauge steel components that form lateral and vertical shear trusses. These elements were produced utilizing the same techniques described for the production of the columns and beams.

The pre-fabrication of these elements enabled a degree of mechanical perfection that approached +/- 1/32" tolerance in establishing the baseline formal geometries. Other mechanical and logistical advantages offered by utilizing the system include self-shoring and stabilization through sequential placement and greatly diminshed construction footprints. The primary frame, lateral, and vertical trusses for the ARMADILLO RESIDENCE prototype were erected in 12 hours by a crew of eight untrained volunteers. By comparison, a similarly sized prototype constructed of wood on an adjacent site took a crew of eighteen over ten weeks to complete and mechanical tolerance levels were in the neighborhood of +/-3/4" tolerance after significant adjustment.

Ultimately, this constructive strategy enabled erection of the structural frame for approximately one third the cost of conventional light gauge framing; an economic parameter that was critical in the realization of the phenomenological and physical aspirations - the result of a *"finely processed product"*

K-FED

But, just as there are advantages with any material or system, disadvantages also exist. The most significant is steel's strength as a thermal conductor. This attribute still remains a significant factor in the regional bias against the material and related systems. It's performance as an excellent thermal conductor requires additional exterior insulation or thermal breaks to overcome this disadvantage; and there are numerous case studies which have demonstrated failures in managing this challenge. Most have to do with a skin system that has been integrated poorly with the frame, trapping moisure. [5]

With this understanding, the frame of the ARMADILLO RESIDENCE was made robust so that the skin did not have to provide any structural capacity in resisting shear. The roof, east, and west facades are pre-fabricated, pre-cut, profile metal panel drapes that cascade over the super structure, remaining isolated from the primary structure. Similarly, the interior finishes are mounted on a series of 22 Guage light guage steel hat channels spaced at 24" O.C. and isolated from the primary structure with 1" deep isolation pads. As the exterior finishes are draped over the frame, the interior finishes are suspended from it. In between these surfaces, a continuous BIBS insulative core is formed providing an uninterrupted R42 insulative barrier between the interior and exterior envronments.

The framing of the cavity and the suspended surfaces is all done with *"raw and indetreminate material"*; all supporting members are mass produced elements that need to be modified at site to accommodate the pre-manufactured super structure and site specific nuances in construction. They also afford the ability to adapt to dimesional variations caused when material price fluctuations require the use of alternative finishes.

WITHOUT BEING TOO REVEALING

As is the case with all DDBC projects, the ARMADILLO RESIDENCE/ RESIDENCE THREE was permitted as a model and the drawings are available to other non-profit affordable housing providers now that the three year monitoring period and post occupancy evaluation has been completed. There are many reasons why this form of limited pre-fabrication was selected. One, the DDBC, as a university affilaited outreach arm, does not have the capacity to bring the replication efforst to scale. The capacity to replicate all DDBC prototypes resides with other non-profit housing providers. For that reason alone, modular and unitized pre-fabrication were eliminated as possibilities since warehousing and interior construction were foreign to those agencies in the local region. An analysis of the economic impact of shipping on development costs[6] and the dimensional constraints imposed in design[7] also influenced the decision.

In 2009 the ARMADILLO RESIDENCE (DDBC RESIDENCE THREE) was sold to a qualifying family for $118,000.00. The pro-forma developed for other non-profit housing providers indicates that they will be able to deliver the project to market at the same price based

Figure 4. Evolution of the construction site illustrating the erection of the pre-fabricated frame, and introduction of other mass produced and pre-manufactured elements.

Figure 5. View of the completed *Armadillo Residence* taken from the northeast.

on current economic forecasting. Fundamental to that objective has been the selective incorporation of pre-fabricated components used in alliance with site modified components. In the end, the strategies employed enabled the skin of the residence to clearly respond to and express the environmental conditions being mitigated on site, while selectively exploiting the merits of pre-fabrication in the development of a framework – defining a clear systemic logic in production and, "*hopefully resulting in an aesthetic that is less plastic and more appealing - without being too revealing.(Hoard)*"

ENDNOTES

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