A Method for the Reuse of Packaging Materials in the Construction of Very Low Income Housing

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Key words: low-income housing, demountable framing, reuse of packaging materials, slum and settlement upgrading, disaster relief, portable architecture.

SUMMARY

Through the reuse of the high volumes of packaging materials, such as aluminum and polyethylene, available and discarded throughout the world, the En-Habit Project is developing a construction technique that addresses three components in Target 11 of UN-Habitat's Millenium Development Goals: housing, sustainability and employment. This technique focuses on a dwelling's framing, decking and roofing. Lightweight materials employed in a demountable manner are scaled for easy handling. The work is intended to improve shelter conditions for those in some of the world's most difficult circumstances. Many millions of tons of these materials are already in the world's landfills with many more to come. Employment opportunities will be available in the collection and reconfiguration of the materials into building components. Applications include slum and settlement upgrading, disaster relief and portable architecture.

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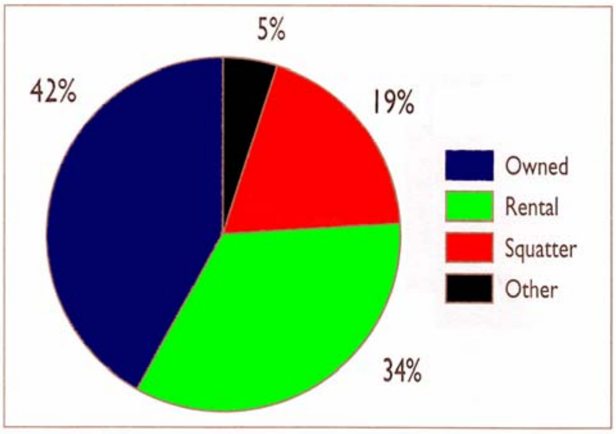
ABSTRACT

Target 11 of UN-Habitat's Millenium Development Goals calls for "sustainable urbanization" and significant improvement to be made in the lives of 100 million slum dwellers by the year 2020. This initiative has been made in response to the severe shortages in housing, available land and services that result from a rapidly urbanizing and growing global population. Governmental debt throughout the world has become a major diversion of funds, leaving many nations without sufficient financial resources to cope with these shortages and the inevitable informal settlements that they cause.

The En-Habit Project will present a proposal that addresses three components of this United Nations initiative: housing, sustainability and employment. The Project is developing an easily understandable method of construction intended to improve shelter conditions for those in some of the most difficult circumstances. The method makes use of frequently discarded and globally available packaging materials. Employment opportunities will be available in the collection and reconfiguration of the materials into building components. The presenter will discuss methods and means, the circumstances under which utilization can be successful, and how the technique's versatility and reusability has a place in the United Nations' call to upgrade the world's slums and settlements in a sustainable manner.

1. INTRODUCTION



Global Housing Tenure 1998-All Income Levels
Source: UN-Habitat

"By 2020, to have achieved a significant improvement in the lives of 100 million slum dwellers."

Target 11: United Nations Millenium Declaration (UN-Habitat-2003)

> "Experience accumulated over the last few decades suggests that *in-situ* slum upgrading is more effective than resettlement of slum dwellers and should be the norm in most slum up-grading projects and programmes." (Un-Habitat-2003)

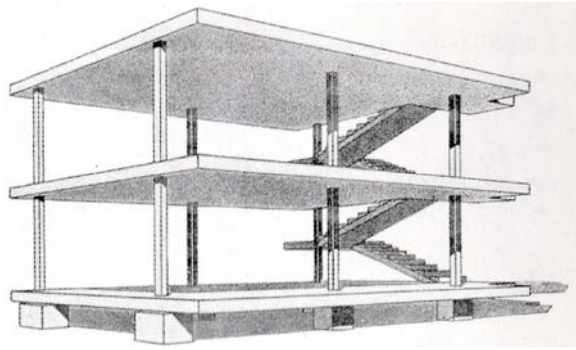
Target 11 of The United Nations Millenium Declaration has placed its focus on 10 percent of the world's almost 1 billion slum dwellers (approaching 2 billion in 30 years, the world's population in 1950 was 2.5 billion). In its 2003 Report on Human Settlements, UN-Habitat goes into a great deal of detail on this matter while repeatedly raising the issue of sustainability. (UN-Habitat-2003) Whatever is to be done about the world's slums, it is to be maintainable long term while many unanswered questions remain about economic forecasts, political stability, and the availability of resources. Achieving any such goal within the caveat of *in-situ* upgrading presents a tremendous challenge. Anything less than the total replacement of a dwelling requires the pre-existence of a sound structure to rehabilitate. How does one upgrade a large number of dwellings efficiently without relocating the occupants?

Target 11's sober expectations may be understandable but that does not make them easy to accept. No one who lives in urban squalor is going to find the 17-year time line any more acceptable than those 1 in 10 odds of finding assistance. If there is any possibility of exceeding the UN's goal, as it is indeed desirable to do, attitudes in the so-called developed world will have to be changed and innovative thinking and action will have to be applied. The private sector must get involved in providing housing so that public works can focus on providing essential infrastructure such as safe drinking water, waste management, transportation and brown site reclamation.

1.1 Background

The dream of providing meaningful and adequate housing for the masses goes back a long way. Indigenous cultures have worked out their own sustainable solutions to the problem in ways that fit the environmental context of their age and place. Contexts that existed for hundreds of years are now changing at industry and technology's rapid pace. Industry and technology can offer more than disruption. The solutions that they offer can respect the diversity of humanity that sometimes seems threatened by the pace of globalization.

Indigenous housing solutions, perfected over large amounts of time, participated significantly in the formation of their respective cultures. As a result, the definition of what people call home is not easily altered, nor should it be. However, the manner in which small scale dwellings are constructed may have to be altered when traditional methods and means lack the capacity to respond in scale to our time's historically unprecedented large-scale growth and movement of humanity. Design innovations that seek to address this problem must do so within a variety of contexts and no one solution is likely to fit all situations. Any design that seeks a broad application must allow housing to evolve and adjust to varying context and unforeseen future needs.

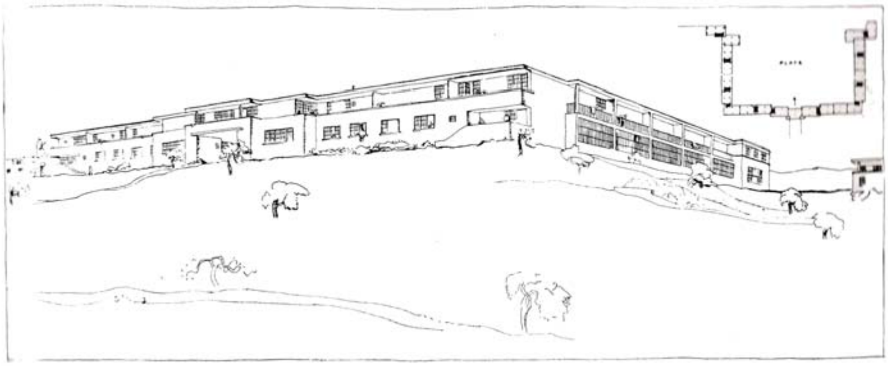


Le Corbusier Dom-i-no Framework
Source: Modern Architecture

Einstein House by Wachsmann
Source: Wachsmann

Le Corbusier's famous Dom-i-no platform system and the all too often forgotten work of Konrad Wachsmann are notable examples of two very brilliant and very different approaches to the mass production of housing. Each system has advantages and limitations that offer important lessons.

Wachsmann, essentially, took the concept of a North European house apart and designed a system of fastenings that allowed it to be shipped over great distances for quick reassembly. These were not the pre-fabricated houses seen on American highways, rolling on oversized trucks, full of empty space inside and completely unreasonable for very long-distance transport. Wachsmann's houses were broken down into manageable parts and successfully shipped as far from Germany as Palestine. Albert Einstein, notably, lived in one near Potsdam. To this day, Wachsmann houses can be found inhabited and in good shape. They are not easily identified as being pre-fabricated. (Wachsmann, 1991)



Le Corbusier Dom-i-no Complex
Source: Modern Architecture

Le Corbusier's Dom-i-no system provided a platform to be occupied and clad in a variety of ways. A standardized, three-deck unit made of cast-in-place concrete could attach to others to form communal arrangements or stand alone. (Frampton-1991)

Both of these approaches were intended for rapid response to anticipated housing shortages resulting from war and mass-migration. There are key lessons to be learned from how they succeeded and how they failed.

Wachsmann's system advantages:
- Demountablilty
- Transportability with very little empty space left in the shipping container
- Little skill required for reassembly
- No on–site water required for assembly after completion of foundation work

Wachsmann system disadvantages:
- Every part was proprietary, leaving little room for regionally available elements
- Every house had to be fully designed and completely fabricated before shipment
- Very awkward post-assembly modification
- Foundation work may require water and concrete

Dom-i-no advantages:
- Versatility
- Well suited for in-situ mass-production

Dom-i-no disadvantages:
- Cast-in-place concrete requires skill with formwork and steel
- A concrete preparation facility must be within a reasonable proximity
- Roads must permit heavy material traffic
- Cast-in-place concrete is not demountable

Grameen Bank Housing-Bangladesh
Source: Aga Kahn

One success story where design, economics and individual initiative collaborate can be found in the Grameen Bank Housing Programme in Bangladesh, one of the world's poorest and most heavily populated countries. This effort targets the rural poor with construction assistance and no collateral loans of around US$ 350. 98% of the participants have repaid their loans and 44,500 houses have been built in five years. A pre-fabricated concrete slab, four columns, and 26 corrugated iron roofing sheets accompany the loan. This combination of mass production and recognition of the individual's resources and initiative is very inspiring. Imagine if the pre-cast concrete components were lightweight; light enough to be easily carried by hand. (Nanji-1994)

2 NEW TECHNIQUE INSPIRED BY AN OLD METHOD

It is clear from the outset that no single approach can be satisfactory in all situations. However, there are certain building techniques that are familiar to and successfully applied by many cultures. These techniques include among others, masonry, various earth techniques such as adobe and rammed earth and timber techniques like post and beam or light frame.

There are advantages to be found in a light framing system which could serve areas where heavier techniques would be awkward or even impossible. Rammed earth, for example, would not work well where the soils are contaminated or land use is so highly concentrated that excavation of any kind is severely restricted. Masonry and methods that use parging require fresh water which is not an abundant commodity in many slum areas.

The development of a cost-effective technique of framing low-rise housing that is sustainable long-term and on a large scale would benefit many of the world's poor, urban and rural. Such a design should have openness to the architecture and be intentionally versatile allowing regional and personal needs to be accommodated. Offering employment along with shelter could relieve some of the enormously complex aspects of poverty. If this effort can also stimulate entrepeneurship at the local level, while employing slum dwellers in the construction of their own dwellings, a relatively modest amount of effort could have a very large benefit.

Post and beam is a framing technique that has advantages over other systems of construction in certain situations:
- -It is, in principle, familiar to many of the world's cultures
- -It can be made of lightweight materials that are easily handled and transported
- -Enclosure is largely independent of structure so that a variety of cladding and wall cavity options can respond to climatic and regional variables
- -The technique has a demonstrated and historic ability to be easily taken apart for reuse, repair and modification enabling a wealth of long-term possibilities
- -The elements can all be mass-produced adding economies of scale
- -Framing can be pre-designed and cut to order at a staging facility
- -Assembly can be quick, without the need for on site water, power or expensive tools
- -Foundation requirements are modest

These advantages become clear when the building site is located where:
- -The occupant may not be able to vacate the site for long, if at all
- -Site access is through narrow and irregular passageways
- -Near site pre-staging for final assembly is difficult or non-existent
- -Power may be unavailable, unreliable or by pirated means
- -Clean water is scarce
- -Soils are contaminated
- -Disaster victims require immediate long-term shelter
- -Temporary shelter is required during new construction

3 MATERIALS

The issue of large-scale sustainability demands that a successful design be based upon thoughtful material choices. These materials should be:
- -Widely distributed, affordably available and accessible to slumdwellers
- -Light weight and easily transported
- -Reusable over the long term with minimal environmental impact
- -Easily fabricated and configured into suitable building elements
- -Not dependent upon large amounts of clean water for final assembly.
- -Capable of fire resistant configuration

Through globalization, the packaging and container industry has distributed large amounts of materials throughout the world. Industry selects these materials for their high durability, workability and low density.

- Aluminum Alloy 3004 (cup), 5182 (top), 5042 or 5082 (tab)
  - -Beverage cans
  - -Recyclable into stress hardened sheets
- High Density Polyethylene (HDPE)
  - -Milk containers, soap bottles, etc.
  - -Recyclable into extrudable sections and sheets
- Polyethylene Terephthalate (PET or PETE)
  - -Soda and water bottles, etc.

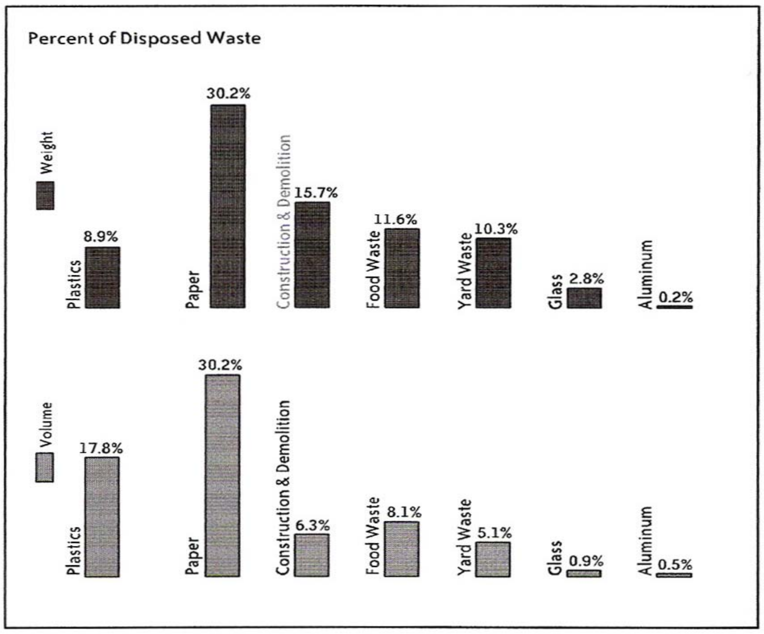
-Recyclable into fiber insulation

HDPE and PET are the most widely recycled plastics. They do not, in practice, qualify as being truly “closed loop” or capable of returning to an original state because secondary processing alters their mechanical performance somewhat. They do, however, retain very useful capacities after secondary processing which requires relatively low amounts of energy. Aluminum, also recyclable with relatively low amounts of energy, comes much closer to being “closed loop” and nearly qualifies as such.

While the plastics are vulnerable to combustion when in direct contact with flame, their self-ignition points when protected are higher than one might think (330-410 °C). This compares well to wood (270-470 °C many variables). (International Labour Organization-2004), (White-1999)

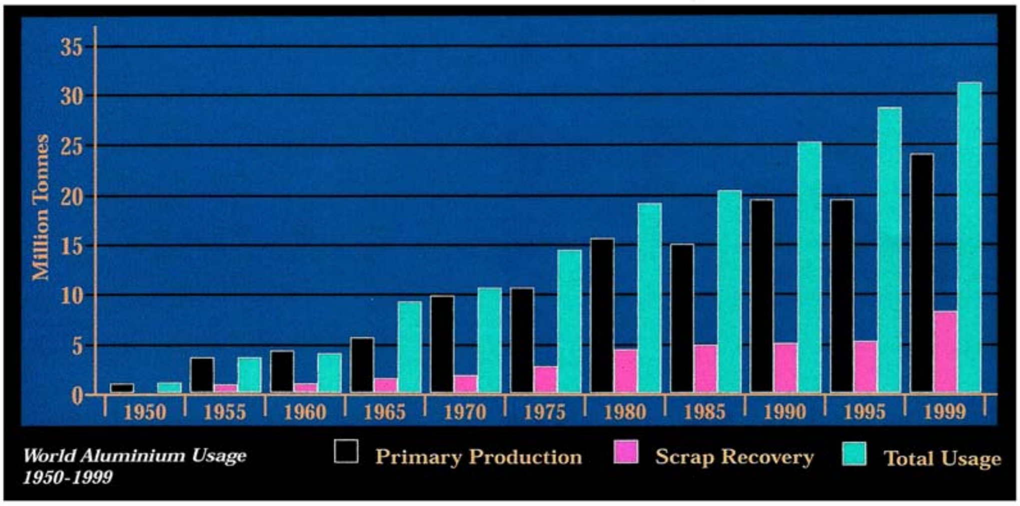
Recyclable Materials In California Landfills by Weight and by Volume, 1999

Plastics are ranked fifth by weight, but second by volume.



Source:California Integrated Waste Management Board

In the absence of recycling, these are all high environmental impact materials both in their primary production process and in their resistance to decomposition in landfills. This is especially true of plastics whose low densities combine with a tendency to be discarded. As a result, they occupy large volumes of space in virtually every landfill on the planet. In addition, Polyethylene is buoyant, clogging storm sewers, threatening sealife and washing up on many of the world’s beaches, even remote ones. The useful qualities that are retained by these materials after reprocessing enable them to be transformed from a liability into an asset. They are, at any rate, widely and freely available to anyone willing to collect them.



Source:International Aluminum Institute

4. MATERIAL ANALYSIS

4.1.1 Aluminum

Aluminum is the most successfully recycled of the three materials because of its great value and versatility. Brazil and Japan have aluminum beverage can recycling programs that exceed 80% recovery. (International Aluminum Institute 2002) Unfortunately, the global average for recycling aluminum cans is much lower at approximately 30%. In the United States, less than half of all aluminum beverage containers are recycled placing an estimated 760,000 tons of energy hungry aluminum beverage cans into landfills every year. By one advocacy group's estimate, this is more than enough aluminum to replace the world's entire commercial airfleet twice. Any such group's data is to be received skeptically but if they are even half-wrong, their illustration is dramatic. This costly metal can be recycled at a mere 5% of the energy used in its primary production and with little or no structural degradation, the same can not be said of steel. It is, by any measure, shameful to have such a valuable and costly metal discarded so carelessly, a great opportunity lies in its recovery. (Gilitz 2002)

Aluminum's chief advantage, when compared to steel, is found in its low density and resistance to atmospheric corrosion. Unprotected steel corrodes rapidly and many forms of protection can be compromised. Aluminum's density relative to steel is approximately 1 : 3. Still, a well-designed aluminum based framework is unlikely to weigh more than half of its steel equivalent, a substantial reduction in the dead load requirements and handling costs. Steel is also very difficult to cut by hand in the field without special equipment. Aluminum's advantages diminish, to some extent, by its lack of stiffness and high thermal movement, although temperature stresses are approximately 30% of steel in a similarly restrained member. The metal is anodic, with an electric potential of –1.7 volts, making it quite corrosive when in contact with many other metals in a moist environment. Direct contact with masonry, anything cementitious, or moist lumber should be avoided as well. Lastly, any design need's to account for aluminum's low modulus of elasticity, a problem in compression or deflection, and for its comparatively low softening point (@130-145°C), an advantage in processing, but a disadvantage in fire. Note that a restrained structural steel beam can begin to buckle at only slightly higher temperatures. (Taylor 1991) (Sanad 1999)

4.1.2 Alloy 3004 (wrought, non-heat treatable)

Aluminum beverage can bodies are usually made of alloy 3004. This is a comparatively soft aluminum alloy with a high Mn content. It is known for its exceptional workability and resistance to corrosion. This is not an alloy that is suitable for structural purposes but it is commonly used by the construction industry for roofing and exterior cladding.

4.1.3 Alloy 5182 (wrought, non-heat treatable)

Alloy 5182 (non-heat treatable) is used on the top or end of a beverage can. It is an alloy with the kind of structural capacity that would be of great use. As far as the can is concerned, this strength is required for a number of reasons, especially at the potential weak spot of the opening's perforation. It is fastened to the body of the can quite securely so that internal pressures may be contained. This alloy was deliberately developed for maximum strength in a thin sheet at minimum cost. It is not by accident that the beverage can industry uses alloy 3004 in combination with 5000 series alloys. The coincidental Mn and Mg content in both alloys simplifies the alloy adjustment when they are melted together in a batch. As a result, the recycling industry makes no attempt to separate these two parts, which would be uneconomical. Mn, Mg and Al content are adjusted after melting.

4.1.4 Alloy 5042 (wrought, non-heat treatable)

The tab, made of alloy 5042 (non-heat treatable) is used to penetrate the perforation on the top of the can. It is the only part of the can that is easily and cleanly isolated. This is an excellent alloy that has structural applications in automobiles. If one had nothing but the tabs off 10% of the cans that annually go into American landfills, one would have around 17480 tons of a great high strength alloy. (tab≈23% of the can by weight)

Location of Aluminium Smelters

Source:International Aluminum Institute

4.1.5 Aluminum Processing

The preceding map illustrates the global availability of smelters. Such areas include regions that are among those most heavily effected by poverty and governmental debt:

- Southeast Asia
- Southern Africa
- Western Africa
- Central America
- Brazil

A cooperative arrangement with the aluminum industry itself is likely to be more feasible than any attempt at small scale secondary aluminum processing in the near term. Scrap remelting, when a particular alloy is desired as an end product, requires some expertise and, frequently, the addition of raw materials. In the interest of keeping the material sustainability loop as close to being closed as possible, and with an eye toward future possibilities, the same alloys used in beverage can production will be used in our design with the majority of the aluminum specified in the form of sheet.

A relationship with the aluminum industry could offer some exciting possibilities. A Company that owns processing facilities globally could participate in a socially aware collection of aluminum cans for recycling. With global distribution and processing in place at such a large scale, it is not inconceivable that aluminum collection drives could be organized internationally with the specific intention of providing materials for low income housing. For example, a portion of the aluminum collected on one continent could result in having an equivalent quantity ordered electronically by a company to one of its facilities on another continent. The public relations benefits for the aluminum manufacturer are obvious, especially in light of that industry's interest in promoting aluminum as a sustainable resource. Importantly, such an effort could be done economically and would help to close the gap that separates primary production aluminum from scrap.

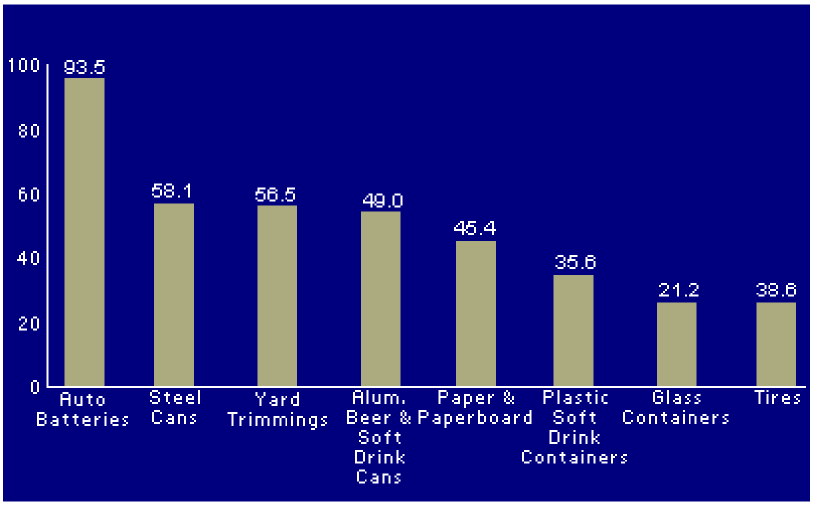
4.2.1 Polyethylene and Polyester

Plastics do not enjoy anything like the emerging success story of aluminum. There are significant problems associated with inconsistent formulations; contamination and sorting that have severely restricted the demand for recycled plastic. Plastic container recycling rates are very low, somewhere around 35% in the United States although many would argue that the real number is far lower because of low demand. Plastic is second only to paper by volume in the ranks of discarded but recyclable materials. Needless to say, this represents a lot of volume with global consumption of polyethylene alone at around 37 million metric tons in the year 1996. (Darnay 1999) There are few success stories here. Two successful products; plastic lumber made from recycled HDPE and Polyester Fleece made from recycled PET, are examples of what the industry refers to as "cascading". In other words, these products are just one configuration of a material that is slowly on the way to the landfill or incinerator.

As material considered for use in this project these plastics, while available in very large quantities, offer many challenges.

- They require a great deal of labor for gathering, separation and cleaning
- Material separation must be very accurate, and there are multiple forms of HDPE
- High expansion coefficients
- They are combustible (ignition point @ 330-410 °C) (International Labour Organization 2004)
- When intended for long term use, they must be protected from UV exposure
- Creep must be accounted for
- The necessary quantity of bottles will occupy a large amount of space

A considerable labor force will be necessary to manage the collecting, sorting and cleaning, offering employment to quite a few people. Once this part of the process has been done, polyethylene is quite easily processed into a variety of forms, through extrusion, and molding. These processes are quite manageable and may be accomplished in modest facilities with good equipment.



2001 Recycling Rates of Selected Materials in the United States

Source: United States Environmental Protection Agency

4.2.2 High Density Polyethylene

HDPE is resilient and impervious to many liquids. It can be either flexible or quite stiff and is commonly extruded and molded into pipes and tanks. With a relative density considerably lower than aluminum's, (Al≈2.7, HDPE≈.95) a successful composite of these two materials would be very light indeed. (Taylor 1991)

If HDPE could be recovered with clear identification for sorting, and in a clean state, recycling it would be somewhat effortless. This is not the case, however. Reliable data on the packaging formulations within the regions most affected by poverty can be difficult to locate. If a degree of cooperation from the corporations that service such areas could be negotiated, such as the sharing of reliable resin formulation data used in their packaging, the process would be simplified greatly. Collections would likely be limited to certain brands and products that could best serve the needs of the project. Typically this would be milk and detergent containers and certain types of water bottles. HDPE containers that had once held dangerous chemicals like pesticides or automotive fluids will have to be rejected as they present a significant clean-up problem and potential hazard to the work force. Given the large volumes of HDPE used globally, these limitations should not lower the material stream of the project below critical mass.

4.2.3 Polyethylene Terephthalate

Recovered beverage containers made from PET have been successfully recycled as fiber for commercial grade carpeting, filter fabrics and fleece insulation. This material "cascades" quickly out of beverage container use because it loses melt strength. The amount of PET that is distributed worldwide by soda and water distributors like Coca-Cola, Pepsi and Evian is very significant. The project is investigating its potential as a useful insulating sandwich panel core for cladding and roofing.

5. FRAMING DESIGN

In our current framing design, the aluminum, specified in sheet form, is brake formed into three section types to clad an interlaced composite of aluminum and polyethylene to form the beam/post. A benefit of this method is found in employing some of the world's many craftsmen who are highly skilled at brake forming. Having sheet metal on hand, along with the necessary equipment and skilled labor, would allow for other building components to be fabricated at the facility, such as roof panels, sills, jambs, vents, and wall cladding.

The aluminum/polyethylene core of these framing elements combines the stiffness of the metal with the dampening elasticity of the polyethylene while containing the excursion of the plastic's thermal movement. Detergent and milk bottles have high polyethylene densities and are good for extrusion. Their polymer lends a degree of cohesiveness to the system's composite post/beam as well as:

- Resistance to loading and impact normal to the plane
- Dampening
- Improved geometrical performance with regard to moment of inertia and section modulus without a great increase in weight. (HDPE relative density ≈.95, Al relative density ≈2.7) (Taylor 1991)
- Shear reduction at the bearing surface where post meets beam

The composite core can be thermally adhered to others in a variety of orientations to create different sections of beams, posts and deck subflooring. These assemblies are then clad in aluminum adding stiffness and load bearing capacity while protecting the plastic from exposure to UV rays and direct flame. Cladding the material in aluminum while carefully accounting for expansion coefficients makes plastic's self-ignition point a more significant issue in fire than flash point which requires outside oxygen. Polyethylene's ignition point is 330°C, well above aluminum's softening point. Even restrained structural steel can become vulnerable at such temperatures. (Taylor 1991) (Sanad 1999)

Without special software and equipment, certain aspects of any composite are difficult to anticipate with accuracy. Laboratory testing will be necessary to measure:

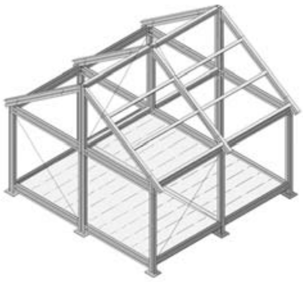
- If the interior core increases resistance to deformation by supporting the metal along its entire section (opinions vary on this point)
- The degree to which HDPE dampens vibration cycles in the composite (aluminum can be sensitive to this)
- The actual fire performance of the post/beam under loading conditions

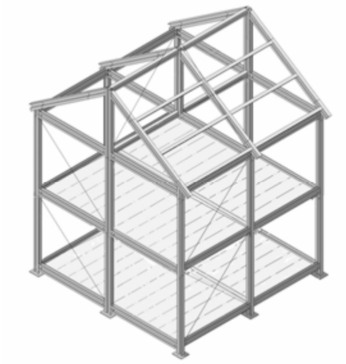
Each beam/post type is capable of receiving a simple fastening system that has been filed for patent in the United States. This, unfortunately, limits the public availability of detail at this date.

Because the system's posts and beams are designed around a conceptual extrusion, they are capable of receiving these fasteners anywhere along their length and from multiple directions. As a result, the beam/posts may be cut without compromising this capacity for fastening. A benefit of the material choice that should not be underestimated is that the post/beams may be cut in the field without the level of effort and equipment required for cutting steel.

The sectional design of these framing members also allows for many different cladding and wall cavity types to be inserted, hung, or otherwise fastened, which includes the direct insertion of self-tapping screws or nails into the aluminum (galvanized steel being more or less okay). Thus, the user/builder is enabled to construct quite a variety of dwelling configurations, using quite a variety of building materials and resources.

Demountability is a key design feature of a post and beam system and is critical to our purposes here. Not only can a dwelling's framework be entirely cut to order before delivery; it can be assembled, disassembled and reassembled and modified many times.





6. APPLICATIONS

6.1 Improvised Shelter and Slum Upgrading

The ease with which such a system could be assembled and modified would mean that a very simple dwelling has tremendous potential enabling the owner/occupant to:

- Bring building materials into dense living situations
- Quickly upgrade a dwelling without great disruption to daily life or loss of site - occupation
- Respond to changes in circumstance by:
  - Moving the dwelling as required
  - Expansion
  - Becoming a member of a cooperative complex as in row housing thereby making more efficient use of materials and land
  - Using building elements that are no longer required for barter

According to the UN-Habitat, slumdwellers frequently put their savings into their home, the so-called “pallet of blocks and a bag of mortar savings account”. It is much easier to sell off demountable building elements should that be necessary than a block wall.

6.2 Disaster Relief

Many pre-fabricated, lightweight enclosures useful for a variety of applications could be brought to the site on aircraft and trucks with a minimum of wasted space and quickly erected and reclaimed for later use once the crisis has passed. Beam/posts can be cut in the field so that modifications can be made on site. The design can not compete in quantity and economy with the plastic tarps typically handed out to refugees for shelter, but it does have advantages in every other way. By keeping an accurate inventory of parts, an agency could specify a variety of configurations according to the nature of the need, before shipment is made to the disaster area.

6.3 Portable Architecture

A successful and proven design may become useful and desirable to markets outside of the world’s poor. Any organization or individual requiring lightweight enclosures that are quickly erected, easily handled and transportable under difficult conditions could find this system useful thereby bringing helpful revenue into the project. Potential applications include:
- Agriculture (including backyard sheds and greenhouses)
- The military
- Mining organizations
- Field research facilities
- Eco-tourism

7. CONCLUSION

One does not have to be an economist to recognize that the world is in a state of rapid economic and social transition. Large numbers of people are urbanizing, seeking opportunity where they think the money is. Housing that is responsive to this kind of fast paced and not always foreseeable change will have to possess certain unique characteristics. For humanitarian reasons, those characteristics must match the pace with a quick response to need. Developing a system of construction that helps people in need by providing jobs and housing, while keeping important resources from being squandered does more than just make sense.

If one has access to sufficient levels of affordable labor, uniquely abundant in the world's worst slums, one can take advantage of freely available materials in ways that would be uneconomical in more developed counties. The same logic that brings the world's garment manufacturers to many of these regions may be applied to the improvement of their living conditions. If a good portion of the money that the developed world puts into a project goes into the pockets of the poor themselves, they benefit in more ways then one. If they are housing themselves with a product that may become useful in other ways, revenue may help support the project.

If the pieces of this puzzle can be brought together, many can benefit.

- The slum dweller, squatter and refugee with their great need and labor capacity
- Municipalities, struggling to manage land use and cope with immigration
- Corporations, who need to improve public perceptions and environmental performance

Many of the pieces to this puzzle are already in place:

- Globally available, durable and affordable materials
- Global infrastructure and expertise
- A workable design
- A genuine and urgent need to improve living conditions

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