Moksha: Design of Disposable Objects for Second Uses as Construction Components

by

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Abstract

Moksha is the Sanskrit word for freedom from the cycle of rebirth. It is the goal of every living being. This thesis seeks a Moksha of the Machine Age. It attempts to explore the possibility of building value into "waste".

The thesis looks at one of the most common items that makes up "waste" - the "disposable" container, and the design changes which if incorporated, can ensure a second life as a building brick. What are the costs and what the benefits? Can generic principles can be derived; principles that would make such a design intervention desirable or even possible? With the ultimate aim of gaining much needed help, in the housing sector, for the poorest of society.

My inspiration comes from poor people, all over the Third World, who fashion almost all of their building material from the discarded objects. The first part of the thesis, records such building activity in present day New Delhi, India.

The study of the squatter building techniques is accompanied by the study of an experiment carried out at the Heineken Breweries, c. 1961, to design their beer bottle such that it could serve as a brick after the bottle had been used. That attempt, had the blessings of the chief executive of Heineken Breweries, one of the biggest names in the business and the technical expertise of the eminent architect N. John Habraken. It produced a completely feasible and very credible product. Yet it never found large scale implementation. Why? Will its contemporary reincarnation in plastic (HDPE) have any greater chances of success than the glass forerunner? These are some of the questions that the thesis looks at in the last chapter.

As architects we are conditioned to seek ultimate proof of our ideas' validity in the world of physical reality. Thus in the course of this thesis I have followed the process of designing a disposable container from the geometric logic of a particular form through the iterations that are needed to rationalize it with respect to the requirements of the manufacturing process, to the final stage of manufacture.

This thesis looks at general questions that surround the issue of designing "waste" for a second life as well as very specific steps needed to design an everyday container such that it could become a brick in its second life.

Thesis Supervisor: William J. Mitchell
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Illustration Credits
In the plush corporate headquarters of Castrol, in one of the upscale office complexes of New Delhi, a presentation concludes amidst much hand shaking and exchange of promises of meeting up for a game of squash. In the two hours previous to the conclusion, the representatives of the advertising agency and a Castrol team led by the marketing Vice President worked out the final touches to a new campaign that envisaged, among other things, changes to the campaign material. Across two million gas-stations all over India, the company would replace all its fixed display units. Eight million pieces of 3-ply corrugated plastic board, each one three and a half feet long and two feet across would become redundant overnight.

That redundancy, in an amazing display of creativity, is inevitably and completely absorbed by the country’s poor. More specifically the urban poor. To build dwelling places. In a city like New Delhi, conservative estimates put the number of people living in shanty towns to be between two and three million. A specific number, of course, depends on the definition of a “shanty”. But the fact beyond nuances of definition, is that incredibly large numbers of people all across the developing third world, the theatre for almost all of the rapid urbanization sweeping the globe, live in homes fashioned out of materials that were not designed specifically for construction. Instead they build out of materials that society has discarded as waste. Materials that cost them little or nothing. For little or nothing is what most of these folk can afford.

That has always been the case and in the foreseeable future will continue to be so. What is more, this phenomenon is not limited to India alone. It routinely happens all across the Third World, in forever amazing ways. Frances Fitzgerald, in her famous book “Fire in the Lake” wrote about the American troops in Vietnam; “For the Americans in Vietnam, it would be difficult to make this leap of perspective, difficult to understand that while they saw themselves as building world order, many Vietnamese saw them merely as producers of garbage from which they could build houses.” 1.
Even if we were to strip away the politics from this reference, we still end up very much in the same way as we did at the end of the scene imagined right at the beginning of the introduction. One section of society looking at another's waste as a fantastic building resource. It maybe argued that the case in point is singular. That quoting Fitzgerald is inappropriate because Americans in Vietnam represented a group of people from a highly consumerist and plentiful society implanted upon a sea of resource-poor folk. The, unfortunate, fact is that the situation is analogous to most Third World situations where economic disparities ensure that the societies end up behaving almost like two distinct nations.

That the phenomenon of reuse occurs so unfailingly across time and geography is surely an indication of some very strong and common causal factors. Wherever large sections of society live under certain, fairly easy to pin down, economic conditions, the reuse of discarded, mass produced items in the construction of dwelling units can be observed.

Surely, this kind of reuse has everything to do with poverty. Once designated "waste", some potentially useful objects can be discarded. While in the developed West, society has enough resources to provide most if not all residents with the wherewithal to construct places of living out of fresh, made-for-the-purpose construction material; that is, quite clearly, not the case in the poor and developing Third World. In such a situation "waste" that can be obtained inexpensively if not free of cost, is always a welcome way out of the situation. Indeed, there is a burning need for such creative thinking and production because this situation is likely to continue more-or-less unchanged for the foreseeable future.
The Environmental Management Perspective

A completely different, yet just as valid, way of looking at the generation of "waste" picture, is from the overall environmental management perspective. Every year the world witnesses a net inflow of millions tons of various kinds of plastics for the exclusive use in the packaging industry. Of this quantity only a very small percentage finds any kind of reuse. Which means that every year the world discards as trash, millions of tons of packaging plastic every year. Waste that is generated by the act of discarding of products that are extremely well designed and often use very high tech materials and processes in their production. In the past, it would be inconceivable to trash something born out of such a great deal of design and production effort. Modern day Economy of Volumes and associated processes designed with very large volumes of production in mind have changed that equation. The entire effort/cost involved with the final product, once divided up between the very large numbers of units produced, results in very small cost-per-unit. This greatly reduces the incentive against wastage. However, it does not change the basic fact that each of the units being trashed is a product of complex design and manufacturing processes.

Processes that at no additional cost, can change the forms of their output. Change the form of the same material which currently upon becoming "waste", pollutes our environment. Finds its way into the deepest of deep sea trenches, gets entwined around trees in the most virgin and unspoiled forests and ends up in the darkest of pits and caves in the world. And proceeds to sit there, quite untouched by the ravages of time, for centuries. Ruining the natural habitat for many species of flora and fauna that would otherwise have survived quite well. In many cases, this waste goes so as far contaminating the soil that our food is grown upon, the water that we drink and the air that we breathe.

To summarize the ideas discussed so far:
There exists in society, both potential and practice of putting "waste" to constructive use. The "waste" prod-
ucts are often results of very complex and sophisticated
design and production processes. Changes at the level of
manufacture can, at no additional cost in either material
or production capacity terms, modify these products
such that they can find a secondary use once their pri-
mary uses are over. Such changes, other than having the
most obvious advantage of increasing their useful life
(and thereby better utilizing the inputs), would produce
the added benefit of diverting the flow of these items
from into trash bins to other destinations. Reducing
thereby the amount of waste generated.

Responses: Decentralization?

No one can really be faulted for asking the next question:
So what are we doing about it? What are we doing about
the millions of bottles that end up in the garbage every-
time someone pours a litre of engine oil or every month
when the cooking oil runs out? Depending on how “we”
is defined, very little at best and almost nothing at worst.

The pattern of garbage handling, currently prevalent, is
largely biased towards large-scale institutional methods.
Most institutional responses to the above scenario would
involve setting up waste treatment plants, devising
ways to cart large truckloads of undesirable stuff out to
politically less vocal places and other such mega strate-
gies. The size of the intervention is hardly surprising
given the fact that the institutions that are entrusted with
environmental management are gargantuan. They are,
almost always huge municipal monoliths and/or their
contractors. The processes they generally employ
require large one-time investment and consequently
these processes are most “efficient” when input/output
volumes are relatively large. The logic of economy-of-
large-volumes that drives much of industrial production
today, becomes the underlying principle of the waste dis-
posal mechanism. Yet, since the “waste” is generated in
very decentralized and thus insidious ways, the suc-
cessful way to tackle it should probably reflect the
nature of the beast and be decentralized itself. i.e.
depend as little as is possible on large scale operations of
collection, transportation and disposal. Instead, the environmental management agencies should probably think of strategies wherein some, if not all, of the waste generated is taken care of in decentralized small-to-medium sized operations. In the case of waste management, especially in big urban centers, a total result achieved by the the effective agglomeration of many small and decentralized components is probably more desirable than a single large venture, even from the point of view of crisis management. In typical third world developing situations civic infra-structure, forever stretched well beyond designed loads, are never far away from collapse. A spreading of points of stress not only builds greater resilience into the system, it also allows civic investment to be spread out over smaller parcels, which could be incremented over time, rather than in large concentrated investments. Yet thanks to the political benefits of grand gestures and the economic benefits of concentration, adequate levels of decentralization are never reached.

The facts established so far are the following: so called "waste" generated by some sections of society (typically those towards the top of the economic ladder) prove to be quite useful for other people. Often this usefulness manifests itself in the self-build homes that the poor put together for themselves in small and very decentralized ways all around the world. This very familiar situation will remain representative of the urbanizing Third World for the foreseeable future. And if the poor were not absorbing, by means of reuse, the waste generated; a lot of it, much more so than now, would end up as major sources of environmental nuisance. Thus it is very fair to say that systems that envisage a second use for objects that lose their value after one use, act as allies of overall waste management.

Relating Back

Before going into the next section and looking at the technology related issues, there is one argument, that often comes up in discussions about low/no-cost housing, that I should present. There are many who argue,
and with a great deal of validity, that housing, targeted at the economically weaker sections of society, is not a technology related issue. That it has to do with policy, financing, market forces and issues such as these. And not much, if any at all, to do with the actual technology of construction. Most of these arguments have eventually to do with two factors: the price and availability of land as a resource; and the maintenance of some basic standards in the construction.

Standards to do with sanitation, use of materials and so on. The section of society that builds from waste i.e. the section that squats illegally upon land, does not use regular construction material for building, in short the section of society towards whom this thesis is addressed, do not follow any of the basic tenets of mainstream real-estate.

For the most part the people living in shanty-towns are squatters and have no titles to the land they occupy. They grab land wherever they can. With the passage of time they are either forced to move on, allowed to squat in the most tentative fashion or, in certain very rare instances, their occupation is given a regular status, and they are made the owners/lessees of the land. The transient nature of their occupation discourages the occupants from investing any of their meagre resources into their dwelling place. They do not have much by way of resources. Even when they do, they are more willing to invest it in forms that they are sure to retain. Consequently a family living in a shanty might invest in a motor scooter or a television (refer case studies), they will be very wary of sinking any funds into the dwelling place.

However they are not averse, quite expectedly, to create for themselves the as good living conditions as are possible. They innovate with new materials for construction all the time. Material that they can obtain at no cost. To create homes that should not be held up for comparison with normal standards of construction, but considered as great examples of the spontaneous expression of the basic shelter creating instincts that all humans have. The
focus of this research is the possibility of reuse of industrial process generated waste to create components that come together to provide affordable housing. Affordable that is, to people who cannot presently afford housing.

It is hoped that the fruits of this research will accrue to this disadvantaged section of society in particular, but also to the larger "society" through the medium of reduced garbage disposal problems and the availability of an additional resource at no extra cost.

**The benefits of second-use**

Clearly, "second use" immediately throws up two major advantages:
Firstly a reduction of the amount of garbage produced, garbage that no one has any use for; with an accompanying reduction of resources that are consumed by the processes that manage these wastes. Secondly the channeling of the waste into some constructive use; with an accompanying decrease in demand for the objects that the "waste" replaced.

Two very strong reasons for us to start thinking of and planning for second uses at larger, societal levels. What are the ways in which the concept of second use could be furthered?

There could be several ways in which second use could be promoted. If we were to think of the problem in terms of the very basic demand-supply model that economists think in: second use could increase either by an increase in the levels of poverty which would actually make it more worthwhile for more people to practice second uses, or by making the actual practice of it easier and more efficient. That too would have the same effect, i.e. more people would be inclined to put objects through second uses. Assuming that the first of the two options is not desirable, we are left with only the second.

Of several ways by which practicing second use could be made easier, one could be the method of empower-
ment of ground level practitioners. "Empowerment" could take many many different forms; all of which, it would not be possible for this thesis to even conceive, leave alone, cover. One example, however, of the process of "empowerment", could be a mechanism for better and more efficient dissemination of useful knowledge. If in a certain shanty cluster the resident-builders had discovered, say, an innovative building application of used bicycle tires, the mechanism, could then spread the word around in other clusters that could use the information. Thus instead of taking years for the community of shanty-dwellers to gain from each others experiences, they could do so much faster if they had efficient channels of information exchange. By this example, I was really trying to point out the possibility of many different mechanisms by which second-use could be more widespread.

One such mechanism, aimed at rendering second uses easier, and one that this thesis will concentrate upon, is the design of a disposable unit for an easy to implement second use.

In order for such a design to succeed, it clearly needs as much support from the people who are going to be responsible for its first use i.e. industry and consumers as it requires acceptance from the second use consumer i.e. the shanty dweller. Both play an absolutely critical part in the operation and without the combined enthusiasm of the both, the chances of any such scheme succeeding are quite remote.

In order to satisfy the first set of interests: the design needs to satisfy all the considerations of material usage, structural strength, economy of material and production time and so on. It must also satisfy a next set of requirements such that a packaging designed for a second use should not consume any more in material or occupy any more space in aggregation while being transported than if there was no second use condition. Simply put, a packaging unit designed for a second use should address all the second use requirements without compromising or sidelining any of the requirements imposed by the pri-
Design interventions: should they be specific and physical or generic and of principles. Specificity could render them compatible to one system only. Limiting the possibilities of reuse.

Design interventions: should they be specific and physical or generic and of principles. Specificity could render them compatible to one system only. Limiting the possibilities of reuse.

Never before in human history has as much design and engineering gone into objects that have as short life-spans as some of the designed-to-be-disposable items of today. The reasons for that are not mysterious. The large production volumes generated by an economy-of-large-quantities driven model, ensure that great design and engineering efforts are worthwhile because they can be applied across large numbers. This facility of being able to invest in a product large amounts of design effort is actually a great ally of the second use concept. And resultant large production numbers ensure a level of standardization not achievable in a small scale operation. Standardization, which is often thought of as a negative for purposes of architectural design, becomes quite a virtue in this case. If incorporated by design, standardization allows all manner of joints and interfaces between individual units to become easy to work out.

**Standardization**

Standardization opens up its own box of issues. Issues that have directly to do with design. Design of packaging objects have a great bearing upon, and are influenced directly by the image the particular brand wishes to convey. Almost always brands will try to find their very own identity in the market. Consequently no brand, worth its name, will be willing to copy another’s packaging design. Thus, at the point of brand-identification, the second-use design principles, if we could term certain principles that, reach a fork in the road. The question here is: should the design features enabling second use be minimalist and generic in nature or should they be very specific and fairly detailed? The answer assumes importance not only because it defines important design philosophy but also because it has a direct relationship to the ratio between all potentially second usable material and the actual items that get designed for a second use. In other words, if objects are totally designed then they will be very specific in nature and a smaller percentage of the global amount will end up being designed for a
second use. If the objects, on the other hand, have a minimum amount of designed intervention, then they will probably be able to include a larger percentage of the global amount. This is only one part of the story though. Minimum intervention probably works best at the level of principles. At the level of the actual application some specificity is always useful, if not absolutely essential. Simply put, interfaces work only if they belong to the same system of design and manufacture, or if they adhere to certain standards. In a situation where standards are difficult to set and almost impossible to implement, its the specificity of a design that will allow for easy jointing and interfacing. The debate, is quite equally weighed on both sides.

The path between the poles maybe dynamic. The Heineken Beer 2 bottle experiment quoted earlier and detailed later on in the thesis, failed because the Marketing managers of the product claimed that its design and use as a brick in a second life would create major image-related problems. They were essentially afraid of losing turf to competition. Yet if we could imagine a situation where every beer manufacture was designing their empty bottles for reuse, then this problem would be solved merely by not remaining unique any more. So at the level of the whole industry, or groups of industries, the path could be of minimum intervention, where there is only one standardized thread ie the principle of reuse. At the level of the actual product that generality of concept needs to be replaced by a specificity that can take care of easy jointing, weather proofing and so on. Specificity, as manifested in the particular form, turned out to be the enemy of the idea's implementation. Yet specificity and a well worked out and detailed form would have been its strengths, had it seen the light of day and gone out into the world.

The adoption of second use design would set up, in turn, a whole set of larger implications. Both backwards and forwards into the environment. The forward side would comprise all the implications that would result from the second use of packaging units, such as any reduction of the quantity of It would be reasonable to surmise that the
current pattern of demand and supply would be affected. While it is true that the logic of second use would promote certain materials over others that could be the topic of another thesis! This thesis will concentrate not upon the materials which will witness an increase in demand due to second use design but upon materials that could be substituted by the supply of products born out of second use design. This concentration is a reflection of the underlying belief that useful material could be fashioned out of currently worthless material.

The questions asked will have to do with the kinds of material that are currently being used by the packaging industry. Of specific interest will be plastic. So, what kind of plastics are currently popular in the industry? What is current level and type of reuse/recycling? I would be curious to know if stiff packaging grade plastic is currently recycled into low density poly ethylene (LDPE) bags? If that is the case what is the kind of economic loss involved? In other words, though the stiff packaging is recycled, the recycling is of a sub-optimal level causing a loss in terms of value deduction. If this loss is aggregated then what is the magnitude that we are looking at? Likewise I will be looking at aggregate figures of the amount of plastic that is a dead-loss every year and work out thumbnail comparisons like “If 40% of all the plastic that is trashed every year, is turned out into second use building bricks, then we could substitute n# of baked bricks.” Comparisons that immediately give us some basis to do rudimentary energy and material flow calculations. Calculations that might/might not produce enough reason to pursue the thread. And is this social benefit enough to warrant any legislative intervention?


Two categories of “waste” reuse: Downstream and Upstream

I would like to introduce two terms which are central to this thesis, as concepts and as category names: Upstream and Downstream.

Very simply: fashioning or modifying useful housing components from as-is "garbage", i.e. garbage that is not produced with any specific intention of reuse, would qualify as "downstream". Flattening out tin oil drums for wall-infill panels, or using waste water stand pipes as columns are examples of the "downstream" variety of reuse.

A much rarer, though not completely absent, form of reuse can occur when right at the stage of manufacture, some feature is incorporated into the design of the to-be-disposed object that lends it to easier and more efficient reuse. Either for very specific purpose or even for re-use in general. This design addition could be thought of as being an "upstream" process.

Designing a container such that it can be used even after its contents are exhausted, and then backing up this move with the introduction in the marketplace of "refill" packaging is a good and fairly common example of designing for reuse. Similarly, designing cardboard containers such that cut-out toys can be made from them, is another example of designing for reuse after the primary use has been satisfied. However there are almost no examples of this line of thinking and manufacturing designed specifically towards construction activity.

Intuitively, construction activity would seem ideally placed to be the target of reusable objects because it uses most materials for the longest periods of time (a brick, for example, is the opposite end of the scale from a disposable orange juice container). Also, construction being more forgiving, in terms of tolerance dimensions, when compared with many other industrial activities, would
seem like a natural home for innovative second uses. The natural affinity of second use and construction is borne out, at ground level, by the many millions of shanties and their occupant-builders. (The shanty dweller will not use a trashed plastic tray to eat in, but will use it as an infill component for walls.) Inspire of this affinity, examples of designing mass produced containers or any other disposable object for a second life in building remain elusive. One of the very few such examples of such an attempt is an attempt by the makers of Heineken beer to fashion their bottle such that it could be used as a brick in an afterlife. (Refer case studies).

**Downstream: Interventions on “found” disposed objects**

“Downstream” reuse is very popular among the urban poor in the developing world. In the following pages I have recorded the construction techniques popular with squatters in the shanties of Delhi.
CASE STUDIES: THREE SHANTIES

The following case studies record visually the average shanty dwelling in the shanty towns of New Delhi. Not surprisingly, the shanty town "real-estate" market, in many ways follows rules and displays characteristics that one would expect from more sophisticated markets. It is non-monolithic and displays many categories and levels of operation.

Although these shanties are situated on squatted-upon land and the occupants run the risk of eviction, there is a fairly high turnover and the transaction amounts (surprisingly high to an outsider) are guided by factors like proximity to work, availability of water, and in many cases the probability of the settlement being granted some kind of legitimate status.

The images and dimensions are from three different units, all situated within the same community. They represent, approximately, the bottom, middle and the top end of the "market".

For the purposes of this thesis it is very interesting to note that the building materials used vary, in the same way as they would if these units were to be built on this side of the poverty line. In fact I am convinced that in the last of the cases the owners could well be on this side of the poverty line! Their choice to continue living in a shanty town inspire of the ability to move out to more formal housing is enigmatic and could well form the germ of another, more social science oriented, thesis! Suffice it to say, that not all residents of shanty-towns fit the TIME-LIFE images of a desperately poor third world citizen.

At the bottom of the table is Raju followed by Shiraj and then the "headman" (Pradhan) of the community at the top. The currency conversions reported here have been calculated at the exchange rate between the US dollar and the Indian Rupee at the time of writing. ie 1$=36 Rs. The conversion is not to be taken too literally because it does not reflect the purchasing powers of the two currencies within their own systems. In January 1997 a bag of cement cost about 120 Rs. (4$) in India, whereas in the US it cost about 10-12$. By this token, the conversion rate vis-a-vis purchasing power is more like 1$=10-15 Rs. This is a good figure to remember when thinking of standards of living, levels of poverty and so on.
Photo: Roofing system devised from used-bicycle-tires, substituting "conventional" materials and techniques of spanning which required the use of long members such as tree trunks.

Materials and Principles in use in shanty construction: featuring three shanties at three different economic levels within the community.

An extremely popular roofing system uses great innovativeness and shows a clear conception of structural principles utilizes used bicycle tires as shown in the diagram and the photograph. The tires are joined together by means of metal wire to form a network. This reduces the effective span, to an extent where plastic sheeting can span. Another layer of the tyre netting is then thrown on top of the sheeting to produce a layer to hold the sheeting down. The netting is kept in tension by means of weights (typically bricks or stone pieces). Thus the use of expensive spanning members, such as trunks of small trees, is eliminated and an effective substitute is found in reused objects.
CASE ONE: RAJU'S REAL ESTATE

The following images depict the dwelling unit of Raju. Its occupied by Raju, his wife and her sister. Raju is a cycle-rickshaw (ie he ferries passengers in his pedicab for a living) driver. Raju makes about 100 rupees (3$, by 1997 estimates) daily. Its a single-space dwelling. Raju and his wife have been married recently and she works as a domestic in houses nearby. More seriously though, they rent the land on which they live. Since displacement, in their case is much more a certainty than in the case of the two other families described later, it makes least sense for them to invest in expensive building materials.

The unit is built up from a framework of wooden poles providing the structural framework and flattened cardboard cartons providing the infill panels. The outer most protective layer is made up of very thin plastic sheeting. Twine provides the fastening between the various elements. The whole unit is completely dismantlable. And if ever Raju and his family were faced with eviction, they could quite literally pack up and go.
CASE TWO: SETTLING SIRAJ

Siraj, a distress migrant, like the other two household heads covered in this section, is in his late thirties. I surveyed his shanty as a middle-order affair; i.e. the materials used are not as expensive as those used for the construction of the headman’s home but are much more expensive than the materials with which Raju built his home.

Siraj makes about the same amount of money as Raju. However, he is self-employed and owns his own tools plant. He also, unlike Raju, “owns” the lot on which he has built his shanty. That is the primary reason behind his decision to invest in longer-lasting materials. His wife works as domestic help in the neighborhood. He has one daughter, eight years old, who goes to primary school.

Another point of difference between Siraj and the bottom of the scale, is the vintage of migration. Siraj has lived in the city of Delhi for almost three decades. That means that he has saved for longer. Often the “saving” is not only in cash form but also a collection of building material that shanty dwellers carry with them whenever they move or are evicted from the place of residence.

Ironically, its people like Siraj, junk dealers, who would form an all important link in the chain of collection and redistribution of the disposable-container-brick that I have in mind.
CASE THREE: THE HEADMAN’S HOUSE

In what is a very close approximation of the social structure of the villages where the men and women whose homes I studied come from, this small settlement of 3000 people have organized themselves into a community. They have an elected leader who they address by the same name that they would have used for a village headman - pradhan.

It becomes apparent after a very short while in the community, why they choose to organize themselves thus. Living, as they do in very crowded circumstances, differences over use of space and other resources break out very easily. The community must absolutely have an internal mechanism to resolve disputes. The headman and his loosely constituted council comprises that mechanism.

The pradhan has been in Delhi for almost forty years. He runs a small mechanical shop repairing pedicabs and their load-carrying variant. His wife runs a small provisions store from in front of their house. They have lived
through a number of eviction attempts and are fairly confident of their long term residence in this community. The *pradhan* wields a fair amount of political clout and is a good friend of the local police constable! I mention all these, seemingly trivial details, because they tie in with the kind of home that he has built for himself. Built entirely of conventional building materials, it represents a level of investment that Raju, my first case, would not be able to afford. It also affords a kind of security that the *pradhan* needs because of the store that his wife runs and the merchandise that they stock. Between the two of them they earn almost twice the amount that the other two families surveyed make. About Rs 6000 per month. An amount that would place them squarely in the middle of the middle class. However the opportunity benefit that they derive from their location keeps them from moving elsewhere.
Alfred Heineken, while on a trip to the Caribbean; to the Dutch Antilles, saw for himself the debris of empty bottles that had carried beer from his breweries. While in Europe these bottles were carted back to the bottling plants and reused. As many as twenty seven times at an average. However the great distance between Rotterdam and such far off places as the Caribbean and Africa did not make reuse in such places viable. Consequently bottles would be discarded after just one use. Heineken was very keen that some reuse be found for his bottles and hit upon the idea of making them such that they could be used as building bricks.

In 1961 he entrusted N.John Habraken to undertake the work. Habraken went through several designs. Some of these were brought up to the model stage. The main issues were, at that point two: first to make the bottle such that its integral parts such as the neck could be accommodated while it was being stacked like a brick; second to
make a bottle such that it had a form that lent itself to mass production. The quantities in which these bottles were produced were critical to the whole cycle of beer manufacture.

The early initiatives were in the direction of vertical stacking. Such as the example below: The final form that was arrived at, after accounting for the manufacturing process and the basic functional requirements. The bottles laid out as units of construction. The final solution stacked the bottles in horizontal courses like regular bricks and unlike the wooden trial pieces.

In an interview with the author, Habraken had recalled that one of the important differences between the ordinary brick and the bottle was the presence of the neck. This created a problem when turning corners. The solution to this problem was found in the corner detail of the log cabin i.e. to let the protrusion stick out.

Photos:
Top: Corner detail for walls
Right: A shelter put together from the bottles
The two bottles: the real cause for the experiments' lack of eventual success lay in the fact that the marketing people at Heineken were of the opinion that the original bottle had a certain image and a related popularity. They argued that a replacement of the bottle would result in a loss of business. Even the most well meaning businessman would not dare to think along these lines. Habraken's sketch for a possible unit made from the WOBO (WOrld BOttle). Followed by the actual unit that was built in Alfred Heineken's estate.
The Designed product and its applications

Possibilities: Why this particular product
Spanning: Arch action and vault formation
Stacking: Walls and nodal details

Possibilities: Why this particular product?

This chapter discusses the disposable container that came out of the design exercise undertaken as a part of the research. To begin with, why did I choose a disposable container as the starting point and why the brick as the termination? There could well have been other objects at the two termini of the design exercise.

It could have been a milk container that became a lamp shade. Or a detergent powder carton that folded out to become a castle for children’s games. Alternatives abound, both as starting and ending points. The choices of a disposable container and a building brick were both based on the possibility of maximum and systematic impact of the idea. There is no doubt that creating lamp shades or cutout castles for children is a more desirable way of dealing with used-packaging than trashing it, yet it is not quite as likely to find large scale application as a building brick.
Two very important factors influenced the choice of first and second uses for the prototype. While in the case of cutouts and lampshades the reused articles would not include one hundred percent of the discarded packets, an end product like the brick would have a greater potential of mopping up all the discards and bringing them into use. So second use as a brick is much more likely to cause much larger scale reuse than the other forms of second use mentioned.

The second factor influencing this choice was the second user factor. The second user in the case of non essential objects such as lamp shades and cutouts would typically be users for whom the objects were not essential. Very often well to do consumers. On the other hand, the bricks are most likely to be used by people that cannot afford regular bricks ie the poor folk. In this way the benefits of the effort accrue, in a substantial part, to the poor. Who are great innovators n improvising construction techniques and material from waste.

Photo: 
The Moksha bottle and the aluminum mold that was used for blow molding.
Also bricks are most basic to the construction process. With a soundly functioning construction system.

**Spanning: Arch action and vault formation**

One of the functions integral to the unit was the ability to form an arch. This ability would allow it to span distances. Arch action was an ally as it was the only way in which a small unit could span over a comparatively large space without the need for a long member capable of taking bending moments.

Arches and surfaces formed by arches have a tendency to implode. They require a tie member in order to stabilize them and provide the necessary tension to keep the arch up. The tie member in the proposed assemblage would be in the form of rubber bicycle tyre tube. And they are a plentifully and cheaply available resource in third world conditions.

**Stacking: Walls and nodal details**

The brick, when stacked, such that its thinner edge sits on the thicker edge of the brick below and so on. This stacking in akin of the stacking of audio cassettes such that the thicker sides are alternately placed on the left and the right.

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Photos:
Top: Detail of corner construction
Right: Overall assembly showing roof and wall schemes.
Note elastic tie for holding roof units together.
Photos:
Right: Assembly showing a cross sectional view of the shelter
Bottom: Bottle on the side
The Design and Evolution of the product

In this chapter I will record the successive design stages that I went through before I arrived at the final product introduced in the previous chapter.

The principles of designing for second use can be applied in different ways across a very wide range of products. The choice of designing a disposable container as potential brick is based upon a belief that such a transformation is more likely to succeed as compared to some other design for reuse. However, this does not suggest that its necessarily the only or even the best pair of choices.
The logic behind the geometry

The design started with a basic wedge shape and then over six distinct and other less discernable stages and iterations, underwent formal changes till it acquired its final form. These stages of development and the design iterations make up this section.

STAGE ONE: CONCEPT

In a major departure from the WOBO experiment the attempt of this thesis was to design a unit that could, with the least amount of supporting material, could form a one story shelter. The unit would thus have to address the dual functions of making up a wall and a roof. A wedge shaped unit could satisfy these requirements of providing roof and walls. The unit would, of course, also require the satisfaction of the primary requirements as a container.

The idea of the unit being wedge-shaped, became the germ of the design.
STAGE TWO: INTERLOCKING UNITS

The next problem that presented itself was of interlocking. How the units would sit in space in relation to one another. While being packaged, during their first life and then again while being laid next to each other as construction units.

Some kind of interlocking mechanism was required because:
- It checked slippage between units while they were stacked as a vertical wall.
- Locking would simplify inter-unit bonding, at times making cementing redundant.
- Interlocking would allow a certain measure of weather proofing.

The idea of interlocking units comes directly from roof shingles, where one unit drains onto the next one. Shingles can overlap easily as they behave as skins. For blocks to do the same, ie drain on one another, interlocking is a workable option, where one of two neighboring units can drain onto the lower unit.
STAGE THREE: INTERLOCKING WITHIN THE LARGER GEOMETRY OF A SQUATTER SHELTER

The actual dimensions of the wedge were determined, accounting for two requirements. One it was designed to contain a volume of 1 litre and second it was designed to form an arch of radius 10'-0'. Thus the wedge shape would be a part of a roofing circle and the cross section would be such that the container would contain 1 liter.
STAGE FOUR: INTERLOCKING WITH THE USE OF NEGATIVE CURVES, FOR COMPLETE FASTENING

The theme of interlocking was taken one further, and the concept of negative curves was introduced. This surface would allow adjacent bottles to slip into each other at the side junctions and would snap together end-to-end. However this design would prove very difficult and expensive to implement as it required a three-way opening mold.
STAGE FIVE: PROTOTYPE 1

A simplified scheme following the principles of interlocking and based on the geometry of the squatter house, was finally chosen for extensive designing in order to actually prototype. This design, in retrospect, had the same problem that the negative curve design did. It had, for end to end joining, an effective void at the base. This void, called “undercut”, had the same effect of hindering a clean mold separation. To actually put an undercut in, the mold would require significant and expensive amounts of re-engineering.
The images on this page and the pages that follow show the CAD model that was developed as a first step before the CAM production. However due to the manufacturing problems stated above this model was not carried on to the production stages.
Prototype 1:
This design was abandoned at a very advanced stage due to the negative space in the underside (in order to accommodate the neck of the bottle behind it in a line-up). Such a void needs a mold that separates in three directions in order to extract the bottle from the mold intact. A three-way-opening mold is considerably more expensive than the regular two way opening mold. The design was abandoned due to the added expense its use would entail.
STAGE SIX: PROTOTYPE 2

In the interest of keeping the engineering simple and reasonably priced, Prototype 1 was modified to avoid an undercut.

Avoiding an undercut also meant a changed geometry at the top. The entire neck region was flattened.

At time of the final assembly, the necks of the bottles would be cut off such that each would fit into the next. Thereby interlocking with each other.

Detailed shop drawings for the mold and the accompanying G-Code for CNC milling of the tool are enclosed in the appendices.
Right:
Exploded view of the final mold
Bottom:
Wireframe:
The final Moksha bottle
Chapter Four: The Questions and some Conclusions

In this chapter I will record some of the “hows” and “whys” that came up during the research. “Cynical” questions that must be answered by every hypothesis. I have benefited greatly from the input of faculty and friends in framing these questions and have tried to include all those that I have come across. However this list of questions is by no means conclusive.

To some of these questions I may have an answer, or even more than one. To others maybe none. It will not be my attempt to answer all the questions or defend the answers that I can think of as being the right answers or even the only answers. That would be horribly presumptuous and hopelessly off-the-mark. This exercise is more about raising the pertinent questions.

The questions belong to two broad categories. Those related to the execution of the idea. Questions about design, manufacture and so on. The second set of questions are about the place of this idea in a larger picture. The macro questions. The macro questions are much more difficult to answer. Most of these questions could be answered in more than one fashion. I will start by asking the larger questions:

What is the issue central to this project? Is it about the housing scarcity? Is it about better environmental management through creative waste disposal? Or is it about something else?

This exercise stands at the cross roads of and straddles all these issues. It does not issue any one of these alone and nor can it be judged by criteria that If this exercise is only about the solution of housing problems of the urban poor, then it probably comes a poor second to any solution that looks at housing from a land-as-a-resource point of view. Yet in urban centers the world over squatter settlements remain a reality. And will continue to remain so in the foreseeable future. Squatter settlements, both their building and their existence, depend on a certain realistic recognition of the lack of resources.

Is the Moksha bottle-brick the only, or the best representation of the idea of design and manufacture for a second use?

The Moksha bottle-brick is neither the only, nor necessarily the best manifestation of the larger idea of designing for a second use. It is, if anything, a very radical representative. By taking a position at an end of the spectrum,
it hopes to prove that the middle ground leading up to it is fertile territory for the idea: I say radical because it takes an ubiquitous object that accounts for well over half of all the High Density Polyethylene (HDPE) used for packaging, and transforms that into a brick. Brick, in its turn, is a key component of construction. If such a transformation is possible then, similar but less widespread uses become easy to picture. Thus it becomes possible to imagine the day when used breakfast cereal boxes can become filing boxes after the most simple operation of tearing along a perforated line, or when computer monitor shells can lock together to become furniture or when milk-jugs can become lamp shades and so on.

All the examples above are management exercises of varying degrees of complexity. Management that involves the transportation of resources from their point of discarding to the point of reuse. The Moksha bottle-brick probably represents the easiest level of management merely by involving a primary and secondary uses, both of which have wide and popular applications.

How legitimate a role does Moksha play in Environmental Management? Will it end being responsible for a greater rate of introduction of plastic into the environment?

OR

Instead of being an instrument that would take care of the wasteful impregnation of the environment by non degradable plastics, what if Moksha causes an incentive to lie with higher production of plastic material to feed the system?

OR

Will a movement like this result in the exact opposite of the desired effect, vis-a-vis environmental management? i.e. will it set up a huge demand for Moksha bricks and thereby causing a larger inflow of plastics into the world?

The second use of the Moksha bottle depends on the first for defraying all costs involved in the production process. The “value” that it acquires at the point of second use is capped by the price of a real brick. In other words the secondary use value of the bottle can never exceed the price that the market is willing to pay for a brick. However, realistically, that cap is only notional because the actual price that such a bottle will command will only be an intersection between the demand and the supply, but within the affordability of the users ie people that cannot afford to use bricks. This realistically low price will ensure that it cannot set up a demand that causes these bottles to be produced exclusively for sec-
ond uses. Thus the second use, as far as I can tell, will never cause an increased demand for the bottle.

What is the need for such a mechanism when the levels of poverty ensure a fairly high level of recycling and resuse in any case?

OR

What is the need for the Design Modifications? As long as there are people poor enough, they will always have an incentive to modify discarded objects; modifications will happen with/without such an intent showing up physically on the object. So why do any modification?

OR

Even now, without any upstream design modification, there happens a great amount of poverty induced recycling and reuse. How would the Moksha idea be a better or even more appropriate substitute? How will this idea represent an improvement on the current recycling practices of the Third World?

The answer to this question involves a concept very basic to the idea of designing for second use. That of value addition at no extra time or material cost. The entire value increment occurs through design. The design changes will cause the product to acquire a higher than zero value. Which will drive it out of the reach of the people whose own time spent in fashioning a shelter, without using these bottles, costs them less than using these bottles. That is one undeniable facet of the problem. The exclusion of the poorest of the poor. They will continue to expend labor and make homes out of value less products. However, this bottle, it can be hoped, will be used by the next segment of the population who so far had been using bricks. Refer case studies: cases two and three. Within this segment it will cause a reduced demand for bricks. Society as a whole benefit from the reduced brick demand through a saving of resources which without substitution, would have been spent on construction.

Though not quite as hard nosed as the one above, another logic in favor of design modification is the preservation of the of human dignity.

What will the distribution mechanism be, given the fact that most of these containers will be used by two very different classes of society?

I have had to encounter some form of this question at
The most popular version is worded somewhat like this: "...if I wanted to build a house out of these bottles, how would I manage to get enough bottles to put a house together?"

The answer lies in a unique system of junk dealing prevalent in India, called "kabadi". Kabadis are itinerant junk dealers that cycle around neighborhoods in the Indian cities and buy from households junk that ranging from old newspapers, journals, tin cans and so on. They then sell this merchandise, again in a highly mobile manner, to households and businesses that have some use for the junk. For instance, they sell the newspapers to businesses that make paper bags. Bottomline, they will identify any benefit that maybe derived from any "waste" item and then proceed to lay the physical delivery route.

Most of the production of waste material capable of being designed for second use is produced in the industrially developed countries such as the USA and western Europe? Whereas most of the projected demand would occur in the Third World. Would not that present a problem?

This answer cannot be given accounting only for a snapshot in time. Industry projections predict a very different picture not very far away into the future. Very peculiarly the plastics industry grows at about thrice the rate of growth of GDP in most economies. So in a developed economy such as those in USA and Western Europe the plastic industry grows at an annual rate of about 7% whereas in India the same figure is about 30%! This will result in very large increases in consumption for the developing countries. So this might actually be the right time to ingrain a second use mentality within the fast growing economies.

Also, within this industry a lot of western countries are exporting outdated technologies to the poorer countries. With the result that plastic related problems that the western economies face now or have faced in the recent past, will almost en masse move to the developing world.

Thirty years ago, with the weight of a large corporation behind it, this idea did not work. Why should it work now?

I have tried to answer this question by going into the differences between the situation then and now in the latter half of this chapter.
Is this the best second use that can be devised for a disposable container? Can the container not be burnt as fuel, as suggested by Prof Bill McDonnough at the "Dimensions of Sustainability" conference? Or be shredded and used as lining for jackets?

The answer to this one lies in the differentiation between reuse and recycling. I would define REUSE, for the purposes of this thesis, as being a process that does not require any major major modification, does not involve tools and plant and does not change the chemical composition of the material. RECYCLING, on the other hand, would include processes that change the chemical composition of the product or involve tools and plant infrastructure to bridge the gap between one use and the next. By this definition, recycling would also require additional inputs of energy into the product in order to produce the second.

Building a shelter out of empty containers represents reuse. It envisages an almost seamless transition, in terms of formal and material qualities, from the first to the second use. This can happen because the second uses' requirements are accounted for within the original design process. This results in no loss of value as embodied in the container.

If on the other hand the same container is burnt as fuel, or shredded for insulation, the cost that was incurred in say giving it a rigid form, becomes a complete waste. In fact it constitutes a negative cost factor, since another agency (the shredding machine) has to be involved in order to render it usable the second time. Whereas reuse accounts for the material and formal qualities of the product and derive advantage from them.

Additionally, reuse does not block out recycling. While the reverse may or may not be true, the obverse always holds. Thus, if a container has been designed to be a brick and also designed from material that is combustible, it can always be used as a brick and eventually burnt. Not the other way around though.

Why use only containers when so many other objects, from toothbrushes to pens to autoparts, are also made to be disposed after a period shorter than their period of structural integrity?

As mentioned in the beginning of the chapter the principle of second use design is the more central thought. And indeed it can be applied all across the board. The choice of the bottle-brick is merely meant to illustrate the
The Specific vs the Generic question and related questions. How much of a single system is appropriate to be designed into the object? Does great amount of detailing cause it to become increasingly redundant without the support of the overall system?

OR

Corporations that have an image associated with the shape of the bottle, would never want to share physical shapes. In which case, is there a chance that some principles can be maintained across designs?

OR

How does the Moksha unit interface with non-designed building material? Thus if on the ground you have a less than 100% situation i.e. for some reason the entire shelter cannot be built out of designed units, is there a capacity within the system to interface with other systems/non-systems? Can a vaulted roof made of the Moksha bricks be placed on a wall made of corrugated paper board and so on?

The third of these three related questions begins to answer the question. The issue under discussion here is standardization. Like most other instances of standardization in history, it has to come either through regulatory intervention or because all the players (or most of the players or the few big players or some combination of all these) arrived at a point where they felt the need for designing interfaces between each others systems. However like camera and lens manufacturers the players might choose not to standardize at all. Mostly its a volume related question.

Of all the questions, this one seems the most hypothetical in the context of this thesis. To begin with, this idea itself is incumbent upon the voluntary efforts of enlightened manufacturers; maybe with a little help from the government.

So the standardization issues depend either on government policy or the cooperation between the manufacturers. Both of which are not the most expected outcomes. Consequently any system design should be very robust. Thus if say, roofing being more difficult to find materials for, the idea catches on such that most second users use the bottles only to make the roofing and use earth or some other material for the walls, the system should still be able to work.

Then there are a host of acceptability issues for the corporate bodies that manufacture/market the product for
which the *Moksha* unit will be a container:

Why should a company switch to this kind of a container in the first place?

OR

What are the costs and benefits that a company would incur in switching to this mode of packaging?

OR

Why should companies be willing to associate with an idea/product like this?

OR

What could be a useful/practical incentive that could induce companies to join in this movement?

I could cite several reasons for the switch. The hardest and most real reason probably is that in material terms it costs the company nothing (refer material calculations) to do the switch.

From society's point of view it results in saving of resources. Some of the savings can reasonably be expected to accrue to the corporation. In goodwill or even, should the government decide to provide the incentive, as savings thanks to tax breaks.

It's an increasingly environment aware, if not friendly, world that we live in. This awareness is very real and tangible. It makes a difference to bottomlines. Corporates live and do business in this world and are very interested in bottom lines. If there is a support for environment friendly moves within consumers the corporations would be very glad to oblige. Thus it would be the first users, who would be the prime movers behind these moves. Consumers who could make a difference to the bottom line. These same consumers, as citizens, could make a difference by creating pressure upon legislative bodies such that they in turn would require the corporations to promote moves such as design-for-second-uses.

I have assumed, maybe somewhat optimistically, a certain attitude in society. I believe that this change in attitudes has happened over the last three decades since the time of the Heineken-Habraken bottle.

Could these objects find an alternate use, other than as a brick to make a shanty with?

A related question would then be: Could these be billed as units meant for building, not necessarily as building bricks for shanties?

The answer is positive. Indeed, these units are designed to conform to certain structural and material logic. As long as that logic is adhered to, the units will work. The units will probably find uses in middle class homes to build small lean-tos on roof tops and so on, before they
find large scale use in shanty towns.

There are, then, the technical questions:

How much more material (HDPE/PET) is consumed when the container is designed in a given form rather than in the most cost/material efficient form?

The answer to this question depends on the form that we are comparing our form to. Compared to the average amount of material/unit volume consumed by the containers of popular brands of motor lubrication oil this design does not consume any more significant amount of material. It consumes more material, than the most efficient form i.e. a cylindrical form, however it packs into cartons more efficiently, reducing freightage related costs. A longer time-frame would allow for a more in-depth analysis. In general terms such a move would not involve a significant, if any, increase in costs.

How long can a structure made of the Moksha brick long?

OR
How long before it will degrade? Will it degrade at all?

This question is more pertinent for cases where HDPE is the material as this plastic has a very large thermal creep and it degrades under the influence of ultra violet light. Given the low end of housing that this unit seeks to address, usual indices of determining longevity cannot be applied. Land tenancy is a very key issue. While the units last for five years or so, most shanty-dwellers do not occupy the same land without eviction, for that long.

What are the nodal conditions when constructing with the Moksha bricks?

Nodal conditions are illustrated in the second chapter.

As I go over this chapter in what will be the last pass, I realize, that I have probably raised more questions than I have been able to provide satisfactory answers to.

That was probably inherent in the nature of the problem. However, in constructing a shelter out of units that have been manufactured via processes completely faithful to the actual processes in the industry, I think an important issue has been addressed. One of practical feasibility. The
research has shown that it is possible to incorporate into the design of a disposable container, features that can facilitate a second use after it has served its primary function. This proof has involved a material and a process that constitutes the bulk of all packaging for liquids.

There is, at the end of this research, ample reason to believe that the time for the idea, exemplified by the Moksha bottle, has come. There is much more to be done, iteratively, before the step from the concept to the real world can be made. That step, I am confident, will be one in the right direction,
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Illustrations 1) Images of Heineken beer bottle and the WOrld BOttle (WBO) reproduced in pages 17, 25-27 have been taken from Garbage Housing