MISAWA HOMES INSTITUTE OF RESEARCH & DEVELOPMENT
TECHNICAL REPORT
vol.12

コストダウンを実現するパコカ・ライン

PA-CO-CA LINE REDUCES COSTS

コアシステムの例(ホームコアの全部材)
demonstrated panel inventory and finished materials for a unit of Misawa Homes' Core

コストダウンの三要因

プレハブ住宅は、高品質・低価格が存在理由と考えられますが、これを達成するための具体的目標、方法などについてはあまりはっきりしていません。プレハブ住宅のコストダウンの三要因は「量産効果」「流通改善」「技術革新」の三つにあると思われます。一般に量産によってコストダウンが達成されるといわれていますが、私共の今までの経験では、それほどの効果が上がらず、今後もあまり期待できないと思っております。「流通」による合理化もあまり大きな期待はもてません。決定的な要因は、技術革新以外にないと思われるのです。

この三つの要因が全て理想的に決まった場合、三要因のウエイトは、コストに対して量産効果10%、流通改善10%、技術革新50%を考えております。合わせてコストは70%ダウンすることになります。一方、コストアップしてくる要因として、開発費、新しい技術を正しく習得させるための教育費、一般ユーザーに正しく伝達させるためのPR費など20%程度が必要です。したがって、終極的に従来工法に比べて50%安で住宅を供給できると思われます。

私共が実際に量産工場を建設してみた結果は、量産効果の反面にある設備の金利、在庫の金利、工場稼働率などの点で不利が多く、あまり効果がありませんでした。

流通の改善についても、流通経路の短縮と運搬方法、在庫管理などをいろいろ考えても、現状規模では、みるべきメリットは多くはありません。私共の場合、合理化の一環として海外資材工場も建設していますが、大きく期待できないのが事実です。最大の効果は、やはり技術革新によって決定的になると思われるのです。

工場で生産することも確かに技術革新の一つですが、現場生産工法をそのまま工場に持込んだのでは無理が生じます。

THREE KEY FACTORS CONTRIBUTING TO COST REDUCTION

High quality and low cost are the prerequisites for prefabricated housing. How to realize them, however, is another question that no one has ever succeeded in demonstrating in a clear manner.

Theroretically, it is established that mass production, modernized distribution and technical innovation are the three major factors contributing to cost reduction. In our experience, however, mass production does not always result in cost reduction. The most decisive factor in cost reduction, in our opinion, lies with technical innovation. Supposing all these three elements were used together in perfect coordination in contributing to cost reduction, we still believe in the proportional distribution of 10% (mass production), 10% (modernized distribution system) and 50% (technical innovation), each percentage representing the degree of contribution, making up a possible total cost reduction of 70%.

On the other hand, we figure approximately 20% is needed to cover minus factors or elements, that is to boost costs such as expenses for research and development, training the staff to familialize them with new techniques, and the cost of public relations to keep the users informed of new developments. Therefore, our die-hard effort in the pursuit of the three elements of cost reduction should culminate in a cost curtailment of 50%.

Let us now explain how we went about in our efforts to bring forth the full effect of these three elements.

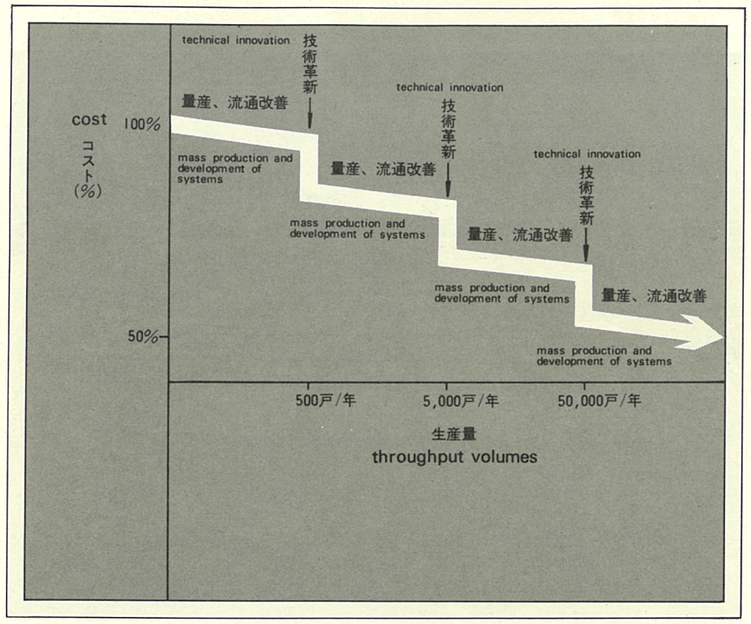
We have built a plant suitable for mass production, and it did not turn out to be a very effective approach to cost reduction because we were rather overwhelmed by increases in interest on invested equipment and on the materials we had to keep in stock, as well as a much poorer working ratio of the plant than we had expected.

Our effort in modernizing and rationalizing the distribution systems in every way possible with respect to, for instance, cutting short the distribution channels, improvements of transportation and stock control, fell short of our expectations.

We have established plants in foreign countries as part of our rationalization program, but we must admit that they are a far cry from what we originally had in mind.

Technical innovation now has a firm grip on our thought as far as cost reduction is concerned. And, we believe in it.

The factory production of prefabricated housing is already a technical innovation. Nevertheless, there is a limit in fabricating things in factories and the same logic applies to our industry. We cannot bring all construction technics being used on construction sites into organized mechanics, which the word, "factory," implies today.



住宅のコストを販売量、部品数、労働の集約化、デザインの多様化と組合せた図
Housing Cost and throughput volume (sales volume, parts quantity, labour intensity, design diversification)

表の見方

①コスト　一般木造住宅を100とすると、パネルシステムで85、コアシステムで70、カプセルシステムでは55となります。

②生産量　生産規模は年産で500戸がフレームシステムからパネルシステムへの切換ができる規模です。5,000戸になると、コアシステムへの切換えができる規模です。そして50,000戸になるとカプセルシステムも可能となります。

③システム　技術の進歩をフレームシステム→パネルシステム→コアシステム→カプセルシステムとし、工法開発を行い、合わせて材料開発も進めます。

④構造　構造的にみると線→面→大きな面→箱へと進みます。

⑤生産単位　生産単位をみると、材料という概念が部材となり、やがて天井・壁という単位になり、最終的には部屋を生産することになります。

⑥部品比　部品の数は一部屋当り約6,000の材料でできていると思えますが、パネルシステムになると100個台、コアシステムになると10個台となりカプセルシステムでは1個になるのです。

⑦年代　年代をあえてつけるとすれば、現在はパネルシステムよりコアシステムへ移行する時代となり、8年後にカプセル時代がやってくるのです。

How to read the charts

① Costs: With the normal wooden house priced at 100, the panel system unit costs 85, the core system 70, and the capsule system 55.

② Throughput volumes: With a production scale of 500 houses, the frame system can be switched to the panel system. With 5,000 houses in production, the core system can be applied. With 50,000 houses in production, the capsule system can possibly be applied.

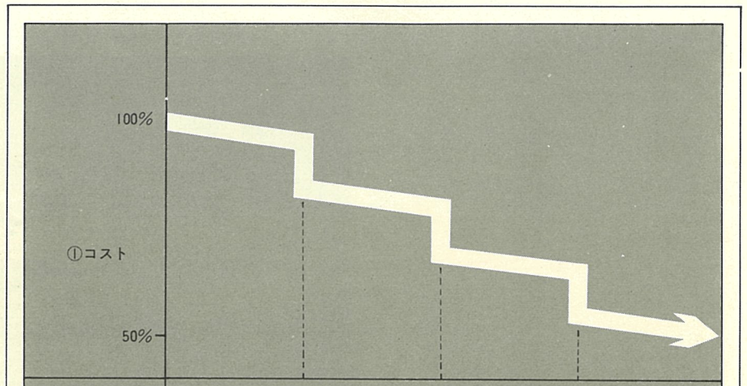
③ System: Technological innovation has been categorized into three parts: frame system, panel system and capsule system. Engineering development as well as development of new materials will be undertaken.

④ Structure: Structurally the pattern extends along a line, from standard frame to panel, to large panel, and finally to box construction.

⑤ Unit of production: The concept of "raw materials" develops into "component parts", "ceilings" and "walls", and finally into "rooms".

⑥ Parts: There are 6,000 different parts per unit. Using the panel system, this number is reduced to 100, and using the core system, to 10. Naturally, with the capsule system, there is only one part.

⑦ Generations: Today the transition from the panel system to the core system is in progress. The capsule age will come in 8 years.



②生産量	500戸/年	5,000戸/年	50,000戸/年	
③システム	フレームシステム	パネルシステム	コアシステム	カプセルシステム
④構造	線の構造	面の構造	大きな面の構造	箱の構造
⑤生産単位	材料	部品	壁・天井	部屋
⑥部品比	約6,000	約100	約10	1
⑦年代	1950年代	1960年代	1970年代	1980年代

住宅のコストを販売量、部品数、労働の集約化、デザインの多様化と組合せた図
Housing Cost and throughput volume (sales volume, parts quantity, labour intensity, design diversification)

技術革新の内容

まず「人間が製作するための設計でなく、機械が製作するための設計をやらねばならない。」という思想転換が必要です。そのための「工法開発」がまずスタートになるはずです。

次の仕事としては、工場生産を容易にするためには、建築現場で使っていた資材だけでは不適当でしょう。そのため「材料開発」が必要になります。一般木造住宅の材料の数はおびただしい数で釘まで入れると100m²程度の家で50,000個あります。自動車のパーツが20,000個ですから、いかに複雑であるかわかります。しかも、野原でこれを組み立てていくのですから大変むずかしい仕事になります。

前述の工法開発に当たっても、この問題を解決するため部品の数を減らす設計をしなければなりません。パネル化、ユニット化、カプセル化ということになります。部品の集約化については、私共の現在の主力商品は約5,000個に集約されています。

今後10年間の主力商品として考えられるものは、約500個に集約化し得ます。部品の集約化は、必然的に大型部品を意味します。今後の単位は、3m×4m程度のパネル、または、2×3×8m程度のユニットとなってくるでしょう。

もう一つの方法である「材料開発」についてですが、まず最初に気づいたのは、建築現場で、組立てるための部材を工場で組み立てるには、あまりにも部材がこまかすぎることです。建築部材は、人力で持てる程度に作られていますが、工場では機械を使う事ができるのでもっと材料の単位が大きい方が良いのです。3m×4m程度の大きさが適当と考えられます。それだけジョイントも少なくなり、当然品質や作業能率が向上するからそのための大型素材の開発が必要となりました。この段階の材料開発とは単に寸法を大きくする合理化でしたが、次に考えられたのがプレハブ用に向く資材の開発でありました。

こんな錯誤をくり返してやっているうちに、この作業が納得できなくなり、ついに一つの材料でこの全ての機能を果たすことを考えるに至りました。

今から5年前は、この材料の可能性について皆目見当がつかなかったのですが、この方法が決定的になることだけは解っていました。

今日、これを私共では、材料開発といい、通称「多機能素材」と呼んでいます。
（テクニカルレポートVol.18参照）

パコカ・ラインの提案

プレハブ住宅のコストダウンは量産効果と流通の整理ではなく、技術革新によるところが大きいと先に述べました。量産効果と流通の整理は、生産の規模化によって、徐々に連続線状に出てくるメリットです。

技術革新は断続的に技術を入れ換えるため、階段状に大幅に下がることになります。

この二つのコストダウン効果をグラフにすると上図のようになります。私共はこのグラフをパコカ・ラインといっています。

ここで問題になってくるのは、技術開発を進めるために、それ相当な開発費が必要になってくることです。しかも、新しい技術ほど開発に金がかかります。開発費は、商品原価として回収して行かねばならないわけでありますが、商品の価格から当然制限が出てきます。大きく入れると高くなります。そこで販売量とのかねあいが、問題になってくるのです。大量販売があって初めて、大型の開発プロジェクトが組めることになります。マスセールスを前提として初めて技術革新は進む事になるわけです。一つ前にも述べた通り、集約化を進めるということは、大型部品となり販売量を伸ばさないと住宅本来の多様化要求を受け入れることができなくなってしまいます。

この意味からもマスセールスが必要となってくるのです。

私共の経験から販売量、部品、集約化、多様化とコストを組合わせるとおよそ上図のようなことになります。

THE OUTLOOK ON TECHNICAL INNOVATIONS

What we need here are designs or schemes planned for mechanical production, not by labor. In this context, "development of new engineering techniques" will be a top priority for the people in our industry who are searching for technical innovations. The next question concerns the materials. To facilitate the production of prefabricated housing in factories, it is necessary for men in the industry to look for new construction materials that are readily adaptable to factory production.

The materials now used in on-site construction are not always suitable for production in the modern concept of fabrication in a factory. Therefore, "development of materials" will be the second important thesis that our industry has to face.

It is amazing to know the number or kinds of materials used in the construction of a wooden house. A house occupying a space of about 100m² needs about 50,000 different materials, that of course includes even small nails. It is also interesting to know that the number of parts required for making a car is 20,000, and the difference shows the intricacy and complications involved in building a house. Besides, house construction is usually carried out on a barren site, without the avail of modern conveniences, further complicating the building process.

The "development of new engineering techniques" must start by seeking designs that allow the use of a smaller number of parts. The panel system, core system and capsule system are three of the possible technical approaches to achieving this end. Narrowing the variety of parts is also an effective means and, in our attempts to do so, we have been able to limit the types of component parts to a total of 5,000.

A new type of prefabricated housing, one which we plan to make one of our major products for the coming ten years, requires only 500 different parts. Reducing the number of different parts to be used for prefabricated housing must eventually result in making these parts larger in size. Our present planning includes enlarging component panels to 3m×4m and component units to 2m×3m×8m.

As for the "development of new materials", our efforts were first directed towards standardizing the various component parts for factory production. Our drive for standardization took its first momentum from our discovery that the many diverse and small parts employed in house construction were probably that way since they had to be handled by manpower. In terms of factory production, the larger these parts could be made the better. In fact, an ideal size for the mechanical production of parts is 3m x 4m or 12m². Component parts of this size will have a smaller number of joints, thereby improving the effectiveness of construction work and leaving room for the improvement of the material itself. Our first target was to make the parts larger in size and fit for production by machine. Then, we reached the stage of improving the material or developing new materials. We have checked every possibility in improving, or replacing with other materials those used conventionally. For example, insulation material was checked from various angles with respect to whether it is really the best material for prefabricated housing, whether it is the best size to meet all requirements, and what will be the best packing material for this particular item.

We have experienced many trials and errors. We were not satisfied with these results, and started to seek out one single kind of material which would perform all the functions we had determined as being necessary in a building material from this experience.

Five years ago, all we knew about the possibility of a new material was that there could be such a material, but we had no hint of what it would be. Today, we have discovered this material, and we have a project team—" Material Development". Such a material could generally be called a multi-functional material. (Please see our Technical Report Vol. 18).

PA-CO-CA LINE

So far, we have come to the conclusion that the cost reduction of prefabricated housing depends much more on technical innovations than on the modernization of distribution channels and mass production.

Mass production and the modernization of distribution channels take effect by degrees, as the scale of production expands, whereas technical innovations are direct and drastic measures for cost reduction. The effects on cost reduction of these three elements are shown above graphically. We call this graph the Pa-Co-Ca Line.

One thing we must bear in mind is the fact that, with technical innovation expenses rise in proportion to the size of the project. The newer the technical development, the greater the expense. These expenses must be included in the cost of the merchandise. On the other hand, the cost of the merchandise can fluctuate within the limit of marketability. The higher the cost of the merchandise, the less the volume of sales will be. This interrelationship between the cost of merchandise and the redemption of research expenses can be kept at a reasonable level only through aiming at more sales of the merchandise. Only mass sales warrant the undertaking of a full-scale research project. There can be no remarkable technical innovations without the support of mass sales. Demands for prefabricated housing tend to diversify, and such diversifications will never be accommodated by manufacturers predominantly dependent on production by mechanical means unless these diversifications are reorganized to adapt them to mechanical production, with this process involving time and money for exhaustive research. Mass sales are the only solution to this diversification—simplification spiral.

From our experience, the relationship between the volume of sales, parts requirements, standardization of parts, diversified demands and cost structure is approximately as shown in the above ghaphs.

カプセルの輸送と強度テストair lift of a capsule unit showing its solid monocoque structure

今後の展開

以上述べてきたように部品の集約化と多機能素材の開発がテーマとなり技術革新は大きく進み大幅のコストダウンが可能になります。ところが住宅の需要の本質的なものの一つである多様化については、どうなるのか心配です。画一的空間に皆住まわされてしまうのではないでしょうか。コストダウンと多様化を両立成功させる方向として二つ有ります。一つは構造体の大幅なコストダウンを可能にした上、コストの下がった分を内外装材、インテリア、設備などの選択性に伴うコストに還元し、多様化する方法が考えられます。さらに一層の多様化に応えられるように、設計要項を定めることによって間取りを規格化しないこともできます。確かに設計手間、積算手間はかかりますがこの費用は構造体のコストダウンで完全に吸収することになります。構造体のコストダウンは間取りを自由に外観のデザインを自由に、そしてインテリアを自由に設備まで組み入れることを可能にしています。コストダウンこそ多様化の原点ではないかと考えているのです。他の方法は、住宅の販売量が多様化を解決することです。今後大量の住宅を供給する会社は、いろいろのタイプのユニットを持つことになるので多様化に応えられます。こういう訳で多種大量販売が可能になるのです。一見規格化を進めているプレハブ住宅は多様化できないのではないかと見られがちですが、ここに技術革新によるコストダウンと販売量をもちこんで考えると、全て問題は解決します。プレハブ住宅産業において、量産流通効果は少なく、決定的要因は技術開発によるところが大きいのです。技術開発は、マスセールスを、前提としています。プレハブ住宅のコストダウンは大きな工場の中で進むのではなく、大規模の研究プロジェクトによってのみ達成すると思われるのです。

FUTURE DEVELOPMENT

As we have explained, the standardization of parts and the development of multi-functional materials accelerate technical innovations and, by the final analysis, contribute to cost reduction.
What, then, about the diversification of demand for housing units? People basically want to live in a house that is more or less different in design and structure from others. Will people have to live in houses of similar design and structure, as the production of prefabricated housing reaches the level aimed at by the industry now?
These seemingly contradictory factors can be amicably reconciled in two ways.
One of them is to first realize cost reduction in the main structural body, and divert the amount saved to provide a wider selection of auxiliary facilities such as interior and exterior furnishings and household equipment. In the same concept, further diversification could be sought by providing customers with a wider range of choice on room styles, provided the customers agree to the basic model of housing structure specified by the manufacturer.
In both of these cases, it is inevitable that additional costs will be incurred in terms of separate design and additional cost calculations. Therefore, these are only possible based on a prefabricated housing with a basic structure which is constructible at lower cost as the result of improvements in manufacturing technology. In other words, cost curtailment made available for the construction of the main body, must be enough to absorb whatever additional expenses customers may require in obtaining a house more or less different from others within the scope outlined above.
The other method of complying with the requirement for diversification of prefabricated housing rests entirely with the efforts of manufacturers toward increased sales. A manufacturer who can sell more units can have capital for stocking additional models. For example, if a manufacturer has to manufacture 100 units of a model house to break even, he can line up 100 different models providing he has the capacity to sell 10,000 houses a year. If he can sell 100,000 units a year, he can stock 1,000 different models. Then, the customer would really have a wide range of choice.
In this respect, too, technical innovations and cost reduction have much to do with sales.
We have explained that technical innovations are a most effective means of reducing the cost of prefabricated housing, compared with mass production and the modernization of distribution channels. Nevertheless, technical innovations are possible only where there are larger sales. The reduction of cost of prefabricated housing is not something to be attained gradually by the improvement of production lines. Only full-scale research can make a drastic contribution.