

Life cycle cost comparisons.

1. General

Steel is one of the most versatile materials known to man. It can be forged, rolled, cast, pressed, welded, cut, drawn, drilled or bent into almost any shape or size. It can be made harder, softer, more brittle, more ductile, stronger or weaker by means of alloying elements or heat treatment. It is the most widely used metal on our planet and society is wholly dependent upon it. Our houses, shops, factories, cars, boats, trains, trucks, bridges and machines all rely upon it. They **can** be made without steel but at enormous cost. Steel is comparatively cheap to manufacture and the iron ore from which it is extracted is widely available. However, there is one problem when using steel.

If it is left unprotected in the earth's atmosphere it will oxidise and revert, in effect, to iron ore. Steel needs to be protected from corrosion.

2. Choice of protection

There are many different ways of protecting steel but in general they fall into two categories; metal coatings and organic coatings. Hot dip galvanizing is a metal coating obtained by dipping steel or iron into a bath of molten zinc. The iron and zinc react together to form alloy layers which are covered by a coating of pure zinc as the work is withdrawn from the bath. This gives an all over protection, inside and outside, that resists knocks and abrasion yet has a probable life in excess of 25 years. These are some of the reasons for choosing hot dip galvanizing, but the deciding factor may well be financial or economic. Before the economics of galvanizing can be compared with other methods of corrosion protection, it is necessary to use the same units of measurement.

3. Relationship between material thickness and surface area

Galvanizing is traditionally costed in units of price per tonne because this is the easiest measurement for the galvanizer to take. Other methods of corrosion protection, such as paint, are measured in units of price per unit area because the cost of application is proportional to the area. For this reason the relationship between units of surface area and thickness of material must be established. Simple relationships are shown in fig. 1. For example, a steel structure with a material thickness of 7mm has a surface area of approximately 37 m²/t.

If the price of hot dip galvanizing is known (usually given in £ or \$ per tonne) a simple calculation will give a comparison of costs (fig.2). If, for example, on a large order, the hot dip galvanizing of a steel fabrication with an average material thickness of 8mm costs 550 units per tonne, this is equivalent to a price of about 17.20 units/m².

4. Two ways of looking at costs

With any project there are two ways of expressing the cost. The first is simply to take the actual or initial cost. This is a useful way of monitoring and controlling costs during the course of the project and, as far as the contractor is concerned, these are the only costs in which he is interested. The owner of the project may have a different perspective. He is interested in the long term costs of the structure; what it will cost to maintain during the course of its planned lifetime. From his point of view a slight increase in initial cost may result in a significantly lower lifetime cost, but how much more for how much less? Fortunately, there are simple ways of calculating the out-come

5. Initial cost

In initial cost terms, how does galvanizing compare with paint systems? Put simply it is comparable with a good paint system. A recent survey in the UK found that hot dip after fabrication galvanizing was more expensive than a very simple “wire bush followed by a primer” coating but was less expensive than grit blasting followed by a multicoat system (fig.3). The reason is that paint systems, especially when applied on site, are labour intensive. The more coats, the more expensive it is. Galvanizing by comparison is not so labour intensive. Being a dipping process it is also more advantageous for thinner section steelwork that has a high surface area per tonne. The large area would take a lot of time to paint but can be galvanized very quickly. Conversely, heavy structural steelwork with a low surface area per tonne appears to be less economic but the argument is not so simple as several other factors are involved.

Hot dip galvanizing is carried out in a factory under closely controlled conditions. Climatic variables such as temperature, humidity and wind have absolutely no effect on the galvanizing process and the finished coating has to conform to international standards. Structural steelwork, by its very name, will be assembled on site, and if it is to be painted, will often be painted on site. This introduces a number of variables to the quality of the paint coating. Temperature can affect curing times, humidity and condensation can affect adhesion but the greatest danger is that inevitably some areas will be inaccessible and not receive any coating at all. Galvanizing covers everything. If painting is carried out off site then gentle transportation and site handling are vital because, in comparison with a galvanized coating, paint is extremely delicate.

6. Lifetime costs

As mentioned in 4 above, there are ways of calculating the benefits or disadvantages of different methods of corrosion protection. The most common method is to calculate the Net Present Value (NPV) of each method and compare the results. This calculation takes into account the cost of borrowing money, the initial cost of protection, subsequent maintenance costs and the lifetime of the structure. It is frequently used by companies to measure the likely outcome of a capital investment project.

$$NVP = 1 + \frac{M_1}{(1+r)^{P_1}} + \frac{M_2}{(1+r)^{P_2}} + \text{etc.}$$

Where I = Initial cost of protective system
M₁ = Cost of maintenance in year P₁
M₂ = Cost of maintenance in year P₂
r = Discount rate

Example:

Take the case of a steel structure that has a projected life of 25 years and for which the discount cost of capital is 5%.

Protection system 1.

Hot dip galvanize to most international standards with a minimum average coating of 85 μm on steel of 5mm or more thick. As galvanizing to this standard has a life expectancy of between 18 and 60 years in the UK*, it is reasonable to project a life of 25 years without further maintenance. Let the cost of galvanizing be a base figure of 100 units. There are no further maintenance costs.

$$\text{NPV} = 100$$

Protection system 2.

A paint system consisting of manual cleaning followed by three coats of alkyd paint. This system has a life expectancy of 8 years and so will need to be repainted three times in 25 years. The initial cost is slightly cheaper than hot dip galvanizing at 90 units. The cost of repainting for the first two occasions is 45 units but goes up to 90 units for the third repaint when the original paint must be removed. When future expenditures are discounted to a present value basis using a discount rate, 56.5 percent, the outcome is.

$$\begin{aligned}\text{NPV} &= 90 + \frac{45}{(1+0.05)^8} + \frac{45}{(1+0.05)^{16}} + \frac{90}{(1+0.05)^{24}} \\ &= 169\end{aligned}$$

Protection system 3.

A superior paint system consisting of blast cleaning followed by three coats of epoxy and alkyd paint. This system has a life expectancy of 11 years and will need to be repainted twice in 25 years. The initial cost is higher than the other paint system (because of the grit blasting and epoxy paint) at 135 units. The cost of repainting is half this value at 67.5 units.

$$\begin{aligned}\text{NPV} &= 135 + \frac{67.5}{(1+0.05)^{11}} + \frac{67.5}{(1+0.05)^{22}} \\ &= 197.5\end{aligned}$$

Protective systems	Hot dip galvanized	Paint (1)	Paint (2)
BS 5493 equivalent	SB1	SF3	SF6
Surface preparation	None	Manual clean Cst2	Blast clean SA2½
Initial treatment	None	Zinc phosphate modified alkyd 35 µm	PVB etch of zinc phosphate epoxy 20 µm
Intermediate treatment	None	H.B. zinc phosphate modified alkyd 75 µm	H.B. zinc phosphate modified alkyd 75 µm
Final treatment	Hot dip galvanize 85 µm min.	H.B. alkyd 60 µm	H.B. alkyd 60 µm
Life expectancy (yrs)	25+	8	11
No. of reapplications in 25 years	0	3	2
Relative initial Cost	100%	90%	135%
Life expectancy and relative cost comparison of hot dip galvanized and two paint coatings in a normal inland environment.			

Conclusion

It can be seen that over a 25 year project life the cost of a “cheaper” paint system is almost 70% more than the cost of galvanizing. Likewise the cost of a more “expensive” paint system is almost double that of galvanizing. In initial or first cost terms hot dip galvanizing is comparable with a good quality paint system. However, when looking at lifetime costs, hot dip galvanizing works out to be considerable cheaper than any other system.

(*UK Atmospheric Corrosively Values, 1986-1991 published by Farm Building Research Team, Agricultural Development Advisory Service, Reading, UK.)

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