CORRODERE.

THE USE OF DIRECTED CORROSION TO SHOW TIME IN ARCHITECTURE.

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SUMMARY: The object of this paper is to demonstrate how the corrosion process can be used in conjunction with an architectural material to show the passing of time in structures. Allowing metals to corrode and produce a decorative patina has been utilised in architecture for centuries. Due to the advancements in the field of corrosion management it is possible to produce a myriad of effects using the science of the corrosion process that would interest architects when designing buildings that exhibit the dynamic of time.

It seems that humanity has developed an obsession with the concept of new. It seems desirable to maintain a structure in its newest form, not only from a structural integrity standpoint, but also in an aesthetic sense. Using a corrosion product as a material introduces another dynamic to a building. It allows the building to grow by letting the material adopt its own finish; a finish that cannot be foreseen but can be predicted with relative accuracy. Rather than having a material which will remain as new for as long as possible you expose an inherent beauty and wonder that comes from letting the environment add the final touch.

This paper discusses three types of corrosion processes; galvanic corrosion, perforation or spot corrosion and the application of inhibitors and accelerators to a metal to produce effects that show time, and add such complexity and interest. In addition, the various colours and effects that are possible are discussed, including the time-to-structural-failure calculations that would be required to utilise a corroding material in architecture.

Ideally this paper aims to change the readers view on the pre-existing negative connotations associated with the corrosion process and discuss how the learnt body of knowledge in the field of corrosion can be applied to other fields; in this case, architecture to incorporate the dynamic progression of time in structures.

Keywords: Corrosion, Architecture, Time, Galvanic, Perforation, Accelerators, Inhibitors.

1. INTRODUCTION

Some artistic painters work in two dimensions and strive to produce a three dimensional (3D) effect; architects seem to be working in three dimensions but with the aim to generate a series of static, two dimensional 'points of view' or 'key images'. Architects, like some artists, seem to be trying to produce a set of still frames that encompass the architect's concepts and ideas. The aim of a building has become to remain in pristine, as-new condition for as long as possible, to maintain the original intent. Time is viewed as the enemy of the new.

Corrosion is very much a function of time and the environment. It is a progression through time to ultimately produce a complete disintegration of substrate (metal) through the process of oxidation. The essence of this process of corrosion is to be used as the seed for dynamic architecture. An architecture that grows with the building, changes with time and ages with its occupants. This paper discusses using the process of corrosion of metallics in architecture to display the fourth dimension; time.

It can be appreciated that a range of possibilities exists in using corrosion processes (and corrosion inhibiting processes) in the methods discussed however this paper limits the discussion to three types of corrosion processes of metals and their possible applications in creating architecture that exhibits time. It challenges the accepted view that corrosion is a negative process and shows that, when used appropriately, the by-product of metal deterioration can be used as a building material in an aesthetic manner that illustrates the passing of time. In addition it discusses the ideas and issues surrounding the use of a using the corrosion process as an architectural material.

The word '*Corrodere*' is Latin in origin and can be loosely defined as: to destroy gradually; consume by chemical action as in the oxidation or rusting of a metal; to eat away or be eaten away. It is the originator of the English word '*Corrode*' which has virtually the same definition today. The connotations of the word corrode are generally negative and corrosion is generally revered as a process to be avoided or adequately dealt with. The word has become associated with decay, deterioration and ultimately expense. The suggestion of using corrosion product as a dynamic architectural material contrasts this current image of corrosion in architecture; it suggests a destructive architecture. This paper explores the meaning behind the purposeful application of corrosion to architecture illustrated by using the existing knowledge of the science of corrosion.

The purpose of this paper is not to suggest an entire building is made from corroding metals, nor is this paper introducing a radically new concept, rather this paper aims to discuss the possibilities of using a managed or directed corrosion process in areas of a design that could benefit from displaying the passage of time in a deliberate manner.

2. CORROSION SCIENCE

Corrosion is the process of electrochemical deterioration of an engineered material. Corrosion in metals occurs due to their tendency to oxidize as a normal consequence of their refined nature, in an attempt to return to the ore state. Metals in the environment exist in a stable state as a metal ore and a vast amount of energy is required to produce metals in their pure state from their respective stable ore state through various processes of metallurgical refining. Metals can then be combined with other metals to enhance properties of the metal such as strength, corrosion resistance, malleability, conductivity, thermal characteristics or aesthetic appeal.

Considering a metal in the presence of air and water, the oxidizing (or corroding) metal (M) supplies electrons to reduce oxygen from the air, and the metal surface acts as the anode for the process

$$M(s) \rightarrow M^{2+}(aq) + 2e^-$$

The electrons can move through the metal to an adjacent area of the metal surface where a cathodic process occurs

$$O_2(g) + 2H_2O(l) + 4e^- \rightarrow 4OH^-(aq)$$

Within the moist conductive environment, the hydroxide ions produced at the cathodic reaction can move toward to react with the metal (II) ions moving from the oxidation or corroding region. A metal (II) hydroxide is precipitated.

$$M^{2+}(aq) + 2OH^-(aq) \rightarrow M(OH)_2(s)$$

A corrosion product is then quickly produced by the oxidation of the precipitate.

$$4M(OH)_2(s) + O_2(g) \rightarrow 2M_2O_3 \bullet H_2O(s) + 2H_2O(l)$$

These corrosion products are not only limited to oxides and hydroxides, but may also include carbonates, sulphates and sulphides among others. These corrosion products can have very distinctive textures and colours which can vary in intensity with time of exposure.

It seems metallurgists, engineers and architects are working against the forces of nature to produce metals, materials and buildings that maintain their new appearance. The advancements in materials that have superior corrosion resistant qualities is an ongoing positive achievement however it is interesting that by using the processes of corrosion discussed below, sections of a building would be working with the forces of entropy not against them.

Humanity is constantly learning. Knowledge is increasing rapidly not only with new breakthroughs in different fields but by applying learnt knowledge in one field to other fields to learn further. Information we have already learnt in the field of corrosion can be speculatively applied to other disciplines such as architecture. Galvanic corrosion, corrosion to the point of perforation (pitting and spot corrosion) and the application of chemicals (corrosion accelerators and inhibitors) to speed up/stunt corrosion are some corrosion topics that have been well documented. These processes are discussed in brief below then examples are used to speculatively demonstrate the ideas in architecture.

2.1 Galvanic corrosion

Firstly, a quick simplification of the galvanic corrosion process. By physically connecting two dissimilar metals and exposing them in an electrolyte, an electrochemical process is induced in which one of the metals corrodes preferentially. This type of corrosion is called galvanic corrosion and the electrical potential generated between the two metals is documented in the Galvanic series or Electro-potential series. The less noble or anodic material will corrode preferentially to the more noble of the two metals or the cathode. The rate of corrosion will increase or decrease depending on the position in the galvanic series and the relative surface area effects of the anodic and cathodic material. It should also be noted that it is often presumed that for elements that are widely separated on the Galvanic Series, the less noble element will corrode rapidly however this is not always the case, as surface area ratios should also be considered.

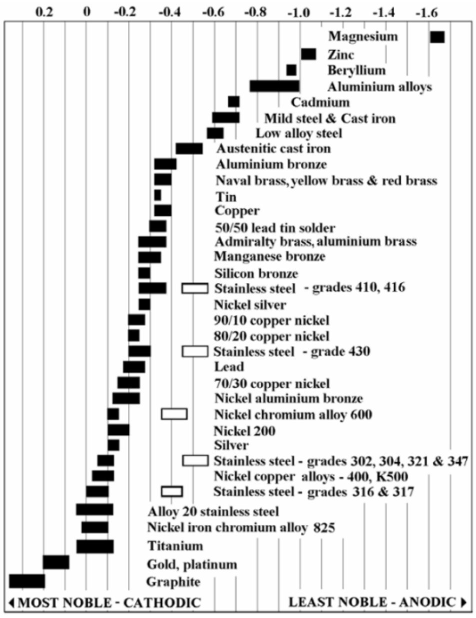

Figure 1: The Galvanic or Electro-potential Series of Metals in Seawater [1]

Interpretation of the series in Figure 1 above allows one to accurately determine which metal will act as the anode and corrode preferentially. Architects use this table in design for material compatibility purposes; to ensure galvanic corrosion does not occur, but the table can also be used to ensure that corrosion does occur

Electrically connecting the two dissimilar metals can be done in a number of ways such as smelting, welding, bolting and folding but to illustrate the point of this section, the process of thermal arc spraying will be used.

Thermal arc spraying involves the projection of small molten particles of metal onto a prepared surface where they adhere and form a continuous layer or lining. To create the molten particles, a heat source, a spray material and an atomisation/projection method are required. Upon contact, the particles flatten onto the surface, freeze and mechanically bond, firstly onto the roughened substrate and then onto each other as the coating thickness is increased.

This direct connection of two dissimilar metals means that galvanic corrosion will occur and further to this the colours that one can achieve from the application of one type of metal or an alloy of two or more metals is interesting. Beauty is a preconception and the deterioration of metals is generally viewed as an ugly process, however, spraying dissimilar metals to metal substrate can produce the following aesthetically pleasing colours:

Table 1. Basic Guide of Colours of Different Galvanic Combinations in Thermal Arc Spraying.

Metals	Colour When First Sprayed	Colour When Corroded
Aluminium + Bronze	Gold	Gold
Aluminium	Silver	Dull Silver
Copper	Red Orange	Greens / Blues
420 Stainless Steel	Dark Metallic Grey	Dark Metallic Grey
Iron	Silver	Dark Reds / Browns
Copper + Stainless Steel 420	Red	Red
Zinc	Grey	White

Table 1 can be used as a quick illustration of the different colours achievable, however two publications that cover the topic in quite some depth are David Scott's books 'Copper and Bronze in Art'[2] and 'Iron and Steel in Art'[3] (with Gerhard Eggert).

Depending on the effect desired and by the clever use of this basic colour guide, selected alloy metallic sprays can be applied to metallic substrates that will act as the cathode. This means that, with careful use of the galvanic series, the spray metal becomes the anode and will begin to corrode. This process is straight forward and relatively simple to construct however the possibilities now for this corrosion process to develop over time are interesting. The proposed use of this process is best illustrated using examples such as the following:

2.1.1 Example 1 – Images that grow with time

This example uses the image of a tree. Copper can be thermally arc sprayed onto a prepared stainless steel substrate through a stencil in the shape of a tree. Iron is then thermally arc sprayed onto the copper in the shape of the tree trunk and branches and the result is that the copper and iron will corrode and produce the image of a tree. The iron will corrode to produce the brown bark and the copper will corrode and form the green foliage. Given time and the effects of the environment this tree will develop its colour and grow with time.

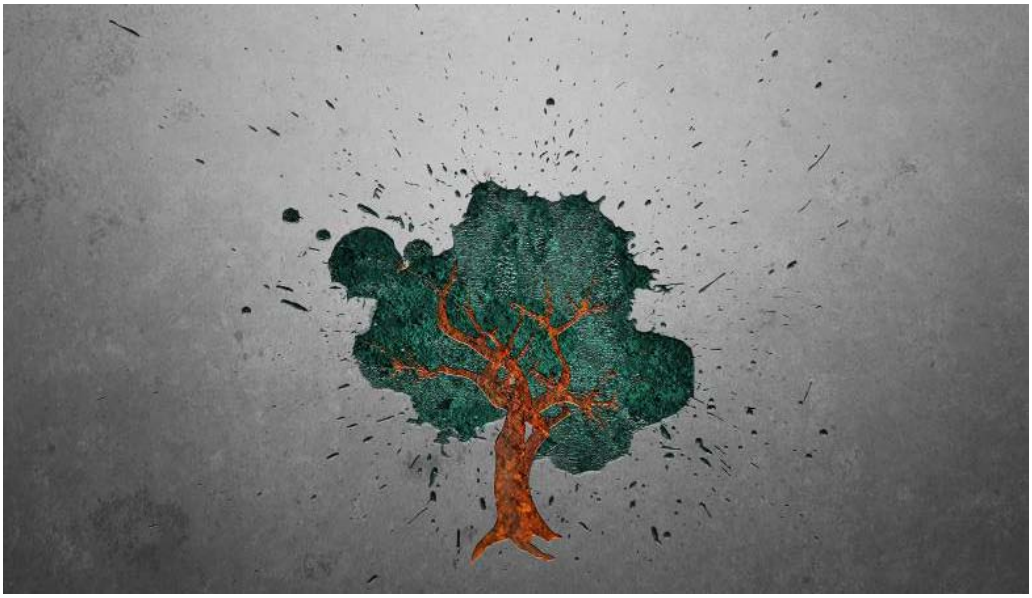

Figure 2 Illustration of what 'Example 1 – Images that grow with time' may look like with time

This process can be undertaken in two dimensional form as illustrated in figure 1 and 2 or in three dimensional such as Paal Grant's Boab tree sculpture that was part of the Gold award winning display garden at the 2009 Melbourne International Flower and Garden Show.[4] Paal Grant, a landscape designer and artist, mentioned that '[...] I used the rusty steel because I like the natural warmth and tones of rust. I believe the rust finish won't date because it has already aged and it blends harmoniously with the environment.'[5]

Figure 3 Paal Grant's winning display garden at the 2009 Melbourne International Flower and Garden Show.[5] Note the boab tree constructed from corroding steel and copper.

For additional effect other metal's corrosion products can also be employed. For example spraying a layer of zinc underneath the copper around the perimeter of the tree the zinc will preferentially corrode and form a white patina or a perceived snow covering.

The example uses an image that would grow with time however the same use of the galvanic corrosion process can be used to produce words and shapes. For example zinc words can be sprayed onto an iron base and eventually the zinc words will corrode whilst the depth of the corrosion product surrounding the words will deepen. The difference in the colour of corrosion product will be clear enough to read.

Please note that these examples are merely simplifications of the idea and careful thought would have to be taken when detailing the connections to the framework to evade problems such as electrical isolation (to prevent unwanted galvanic corrosion) and water collection (to prevent staining of panels) to name a few.

2.1.2 Example 2 - Graded limestone stone wall that stains with corrosion product over time

The concept for this wall is to allow the metallic chips that are placed purposely within the limestone wall to corrode and spill their corrosion product over the limestone, thus colouring the wall with time.

The wall is constructed from graded limestone rocks that are placed within a metallic mesh enclosure. Copper and iron chips are mixed in with the limestone rocks during construction of the wall and water is channelled to the top of the wall. The water percolates through the limestone wall and comes into contact with the metals allowing the corrosion process to begin. The corrosion product subsequently spills out, finding its own path of least resistance and stains the limestone wall with the colours deepening with time. Due to the limestone's inherent light colour the corrosion product stains would show clearly.

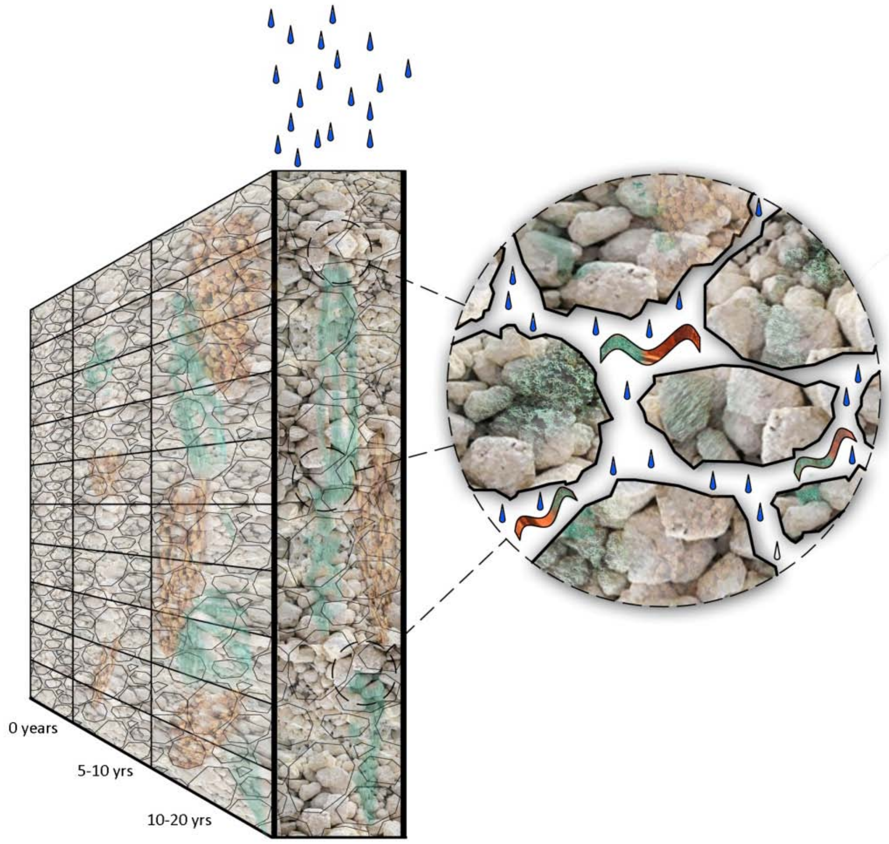

Figure 4 Schematic drawing illustrating concept of limestone wall being purposely stained by corroding steel and copper over time.

It should be noted that this is an illustration of a concept only and that the idea embodied in this simple illustration can be applied in other scenarios.

2.2 Perforation calculations and structural strength

Another interesting use of the corrosion process in architecture is to allow a metal to corrode to perforation. Architects may find interest in the perforation of metals with time to allow light, sound, air, water to penetrate. This will change the qualities of a space over time. For instance the penetration of light into the space will get greater with time as the panel corrodes.

The immediate problem with proposing that architects use corrosion to the point of perforation in metals as a design tool is the fact that, as metals lose their structural thickness, they weaken and possible structural failure is a concern. There are many ways that this issue can be overcome including making the panel or section that corrodes non structural, similar to the way that decorative windows such as stained glass are situated, and include calculation of lifespan to structural failure and anticipative replacement at the design stage.

It is possible to estimate, with accuracy, a corrosion rate of a metal in an environment. This corrosion rate can be used to perform thickness lifespan calculations which can indicate to an architect or engineer when a panel will need to be replaced before its fails structurally. Perhaps the most common method for estimating material corrosion rate is to immerse the proposed material in the proposed service environment for a predetermined time period and to evaluate its performance after removal from the environment. The prediction is only as good as the ability of the test to duplicate the actual environment.

When metals or alloys are being evaluated, the change in mass is obtained by weighing the specimen before and after exposure and converting that mass change during the exposure period to a penetration rate. The specimen is thoroughly cleaned before and after to ensure that all dirt, debris and corrosion product is removed.

The following equation is used to estimate the corrosion rate:

$$R = \frac{K(m_b - m_a)}{A(\Delta t)\rho}$$

where: (6)

R = penetration rate (mm/y)
m_b = mass before exposure (gram)
m_a = mass after exposure (gram)
A = total exposed surface area (mm^2)
Δt = total exposure time (hours)
ρ = density (g/cm^3)
K = constant for unit conversion

This equation is a guide to the penetration rate only and considers that penetration is uniform or even across the specimen surface. It is dubious to assume that no areas of greater and lesser attack occur because at a microscopic level some materials have slight imperfections in which localised corrosion may manifest. The implication is that the maximum penetration rate may be several times the average penetration rate.

This basic method above is one of the many tools that corrosion engineers can use as preliminary calculations to estimate when a material might fail structurally. There are many other factors and more accurate calculations that can be performed and it would be recommended that annual inspections be undertaken to check the progress of the corrosion.

An example of these calculations being carried out was undertaken by New Zealand Heavy Engineering Research Association (HERA) on a sculpture called 'Per Capita' by artist Cathryn Monro in Wellington, New Zealand. It was calculated that the ten tonne sculpture would have a total steel loss of 1.8mm over 100 years. Considering that the thickness of the weathering steel of 'Per Capita' is 40mm, the estimated washed corrosion rate was deemed to be acceptable. However, assuming a worst case scenario, whereby the sculpture was sheltered from being washed by the rain but still exposed to the wind and salt from the sea, the total estimated steel loss over 100 years was 13.5mm[7]. Although the difference in steel loss was considerable the thickness of the material meant that this loss was not going to become a structural issue. Other issues that can accelerate corrosion and need to be taken into account include excessive handling, changes in environmental exposure (rain, pollution, ultraviolet radiation), the site location and vandalism.[8]

Using this calculated information, a number of possibilities in design are possible, where corrosion will be allowed to occur to the point of substrate perforation and this is illustrated with an example below.

2.2.1 Example 3 - Perforation of metal panel over time

Sheet metal can be left to corrode to the point of perforation. Depending on the design of the panel and its placement, this perforation could possibly let in light, water and external air into a space over time. The interesting thing about this is that the process of perforation will be constantly changing the quality of the space and the experience of the space will never be the same due to this process of change with time.

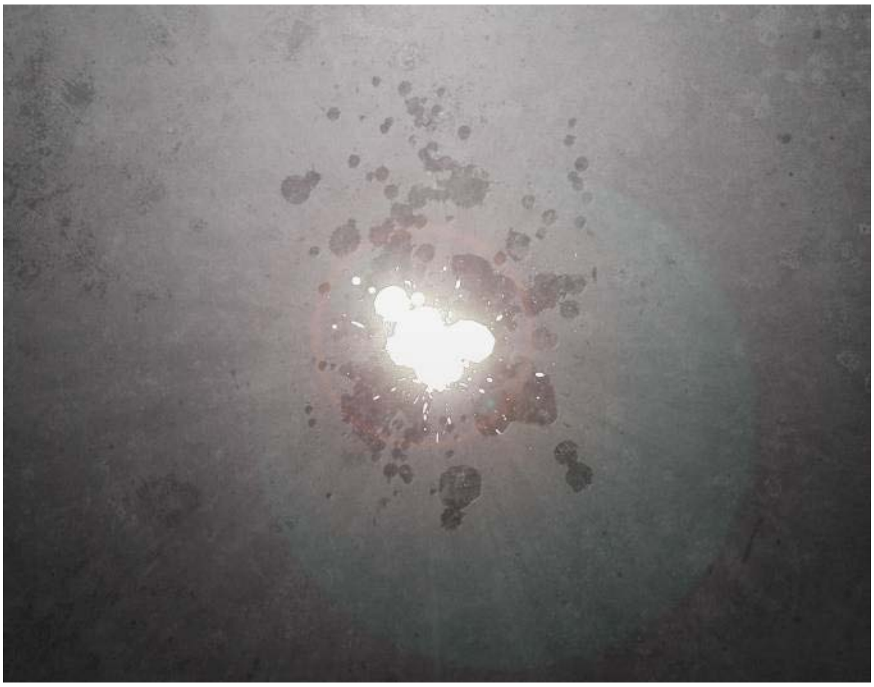

Figure 5: Illustration of what the end product may look like of 'Example 3 - Perforation of metal panel over time'

2.2.2 Example 4 – Pivoting arm activated by anticipated structural failure due to corrosion

This example is essentially a pivoted arm that has a large counter weight placed to the rear of the arm. The pivot point may be held up by a vertical column either side of the arm with the pivot pin connecting the two columns and holding up the arm apparatus. The counter weight is designed to weigh more than the weight of the arm. The counter weight is constructed in such a manner that it has a series of arms itself that are fixed to one another at increments of 90,75,35,10 degrees running from perpendicular to the arm through to in line (or parallel) with the arm respectively (see diagram below).

The counter weights arms sit on a series of plates that are welded to the vertical columns in such a fashion that the top plate is holding the first counter weight arm (90˚) which corresponds to the arm being in the horizontal position. The plates are designed to corrode to the point of failure with each place being thicker than the next. Upon structural failure the first counterweight arm will swing through the plate and the second counter weight arm will come to rest on the second plate. This process continues until all the plates have failed and the main arm is in the vertical position.

This example utilises the physics of structural loading of a plate and reducing the plate's structural depth to the point of failure through corrosion. The corrosion rate can be obtained through the weight loss coupon method and given the dimensions of the plate and the known loading one could calculate when the plate will fail given that loading. There are many other factors that need to be taken into account such as changes in the environment, point corrosion occurring, stress corrosion cracking, welding differences etc., however the general concept has merit by using the science of the corrosion process to create objects that physically show the passing of time.

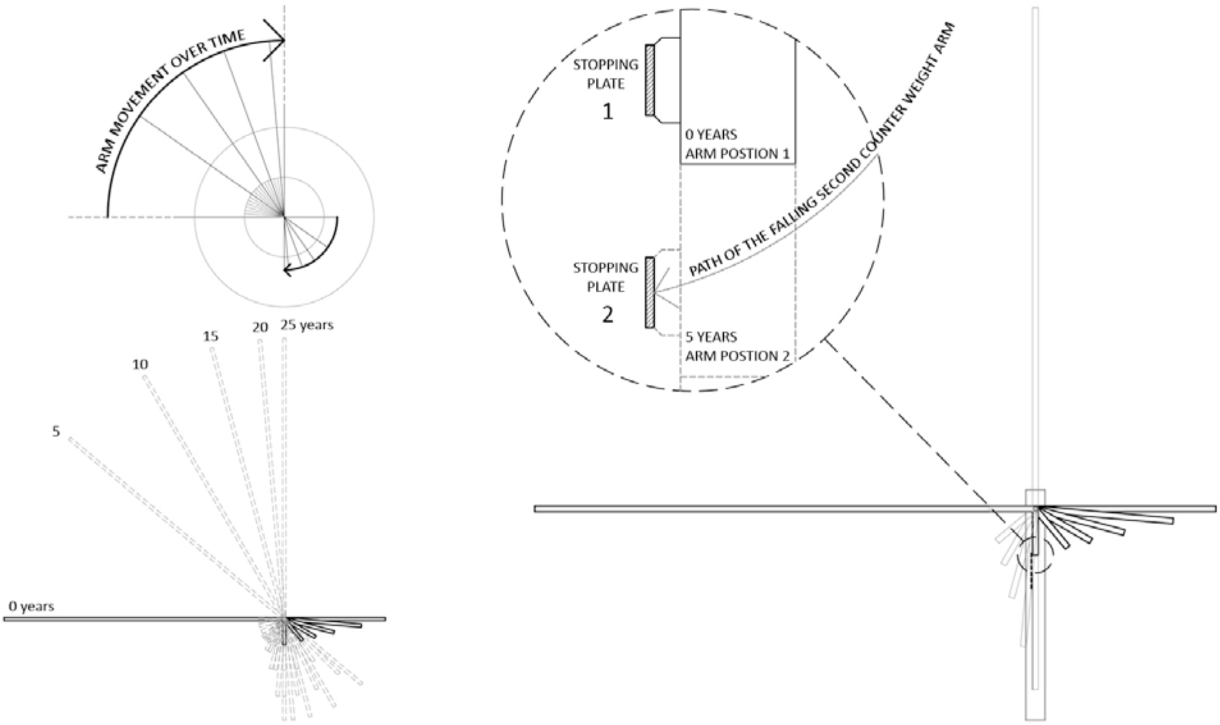

Figure 6: Schematic diagram of the pivoting arm actuated by structural failure caused by planned corrosion.

2.3 Application of Corrosion Inhibitors and Accelerators to stifle/speed up corrosion in selected areas.

The use of chemicals that accelerate and inhibit corrosion to a selected substrate is perhaps where the most potential in architectural application lies. Corrosion inhibitors and accelerators are used in two different facets of corrosion science.

Corrosion inhibitors, as their name suggests, are chemicals that have been developed to inhibit or stunt the corrosion process in metals. Chemical inhibitors are essentially electrically charged particles that are attracted to the metal substrate that create a protective film over the metal that inhibits the oxidation of the metal substrate in the corrosion process. Inhibitors often work by adsorbing on to the metallic surface, protecting the metallic surface by film formation and are normally distributed from a solution or dispersion. Corrosion inhibitors slow or retard the corrosion processes by either:

- Increasing the anodic or cathodic polarization behavior (Tafel slopes);
- Reducing the movement or diffusion of ions to the metallic substrate;
- Increasing the electrical resistance at the metallic surface, it is important to note that coatings and waxes may also act as corrosion inhibitors

Corrosion accelerators are generally used in experimentation and testing to accelerate the process of corrosion to obtain results more quickly. There are a number of chemicals that exacerbate corrosion and promote metal loss. For example salts such as ferric chloride, cupric chloride and sodium hypochlorite are good corrosion accelerators to carbon steel and can be used to promote directed corrosion. In summary, mobile anions with highly soluble salts which can readily penetrate and cause breakdown of protective films are found to accelerate both processes.

These various chemicals (corrosion inhibitors and/or accelerators) can be applied to metallic substrates much in the same way that an artist would apply paint to a surface to produce an image. The result is the development of corrosion products of metals at different rates; from the maintenance of a shiny metallic surface (corrosion inhibitors) or heavy corrosion product that is rapidly progressed resulting in an image or letter of a word is thus put into focus.

2.3.1 Example 5 – Applications of using corrosion inhibitors and accelerators in architecture to show time

This example illustrates its point using a building that has already been constructed. Soccer city is a stadium in the Soweto area in Johannesburg, South Africa and an icon at the recently concluded 2010 world cup of football. It is currently the largest stadium in Africa with some 94,700 seating capacity. Architects Boogertman & Partners and Populous designed the stadium to resemble a Calabash which is an African pot or gourd. Below are some images of the stadium.

Figure 7: Illustration of Soccer City, Johannesburg.

Figure 8: Close-up image of the stadium

The palette of earth tones chosen for the concrete cladding panels of the stadium could be replicated by different metallic corrosion products of metal alloy substrates (refer Table 1). This would essentially produce a metallic external surface or skin that would readily accept corrosion inhibitors and accelerators in the form of words or images that encapsulate a memory or moment of an event. This draws interest because instead of having a static three dimensional building the external skin becomes a dynamic narrative or story board that talks about the past experiences of the stadium whilst maintaining its aesthetic rationale. Like the human characteristics of memory the images will be strong at first then fade slightly with time but still remain etched into the external fabric of the stadium. Once the images require replacing as new events or moments occur inside the stadium the surface can be media blasted and a new image applied.

3. NOTES ON ART, ARCHITECTURE AND CORROSION SCIENCE

The above processes of corrosion and their applications in architecture are just a few of many facets of corrosion that can be used as a design tool. The processes discussed can be used in conjunction or in isolation to produce a myriad of effects that show the passing of time due to the inherent nature of corrosion. It is important when suggesting a different way of looking at a topic, such as corrosion in design, that one supports the idea with reason and rationale. Essentially this section covers the why; why bother using corrosion as an aesthetic option in architecture?

3.1 Time through Growth

The corrosion process can be likened to a language. A material's ability to have associated meaning, and preconceived ideas or notions is the essence of why material choice in architecture, sculpture and art is so crucial. Using the corrosion product of metals is interesting, it introduces a dynamic aspect to the architect's material. A material that once applied can develop over time in a reasonably predicted and particular way given the application of accumulated knowledge of the process of corrosion. Time becomes a design element. Time as a design element adds meaning, depth and beauty to projects.

Corrosion product can be viewed as almost an organic process. It requires fuel (oxygen and water) and, although results of its growth or propagation can be estimated quite accurately, it has a certain randomness that a living organism such as a plant may have. Essentially, given a number of base criteria or 'rules' in its manufacture or construction, the use of corrosion product in design can grow dynamically to give unforeseen results. This hidden end product develops mystery and suspense throughout the life of the building and keeps a building interesting.

The process of corrosion embraces time, delivers change and adds layers of meaning to a structure; it shows an 'aliveness' of the building through this process of change.

3.2 New Obsession – Allowing materials to adopt their own finish through the process of weathering.

It seems humans have an obsession with the concept of new. As Architects we seem to be working against the forces of nature to produce buildings that maintain their new appearance. It is human nature to want new possessions from an aesthetical point of view (own items that appear new for as long as possible - associations with wealth and power) and a structural point of view (own items that will not fail structurally, pose risks to own health and others) which is not a bad or a negative aspect of human behaviour. However, in our fanatical obsession with the new it appears we have overlooked something; the inherent beauty and wonder that appears from allowing a material to adopt its own finish, a finish that cannot be foreseen. We should be working with the forces of nature not against them and allow the inevitable and random forces of the environment to develop the building finish as the final touch in construction.

Mohsen Mostafavi, the Dean of the Graduate School of Design at Harvard University, and David Leatherbarrow, a Professor of Architecture at the University of Pennsylvania, have written about the topic of weathering in their book 'On Weathering'. A number of interesting sentiments are included in this book that critically discuss the continual process of refinishing of the building by natural forces and how this adds to, rather than detracts from, architectural meaning. Essentially Mostafavi and Leatherbarrow challenge the accepted view that once a building has reached final completion, the building has finished construction. The authors suggest that after the final completion stage of a building the process of weathering essentially completes the building's finishes; 'Finishing ends construction, weathering constructs finishes.'[12]

The inclusion of a material that shows time into an art piece or building means the observer / occupant becomes part of a process of change. Mostafavi and Leatherbarrow touch on the subject of a building acting as a narrative 'Age value can be identified with the notion of aging as an enhancement and the idea that the various markings and layers of a surface record and allow one to recollect earlier stages in the history of the building and the human life associated with it.'[16] Buildings that show weathering of materials (like materials that are permitted to corrode) become working time lines that can record and show the path of time.

3.3 The Psychology in Interpretation of the Process of Corrosion

Although the author is not a psychologist this section of the paper is briefly touched on to invoke thought into the human psychology involved in the interpretation of the process of corrosion, or in broader terms; discuss the understanding behind the general ongoing entropy that surrounds humanity on a daily basis. It is widely accepted that the universe is in a constant process of energy recycling or conservation of energy at all levels. Essentially all matter can be broken down into basic building blocks called elements and all elements have a safe state that they reside in. As discussed above metals occur in their ore state and energy is used to create metals which in turn corrode and return to their ore state. Organic matter, such as humans/plants/animals undergo a process of birth/aging/death/decay which has been organised into a food chain type explanatory diagram. The process of decay is inherent in all of us and we experience it every day using the variety of senses as a human.

An interesting point is that some artists, whilst working in two dimensional media, use subtle psychological ploys to engage with the observer. Examples of this are found in many art movements, especially expressionism that uses colour and focus to add feeling and emotion or found in the use of recognition tactics; where the artist's subject matter attempts to induce a sense of déjà vu. This is common in many paintings and is a psychological addition that taps into the unconscious to evoke emotion. Very powerful in generic themes like John Constable's 'The Hay Wain' painted in 1821 of a farm yard setting, or the numerous 1800's paintings of ships (a common sight at the time) were perhaps chosen because they evoke emotion by tricking the mind into recognising the subject matter.

The corrosion of metals will at some stage affect us all. Many people will have a strong association with corrosion and their childhood memories such as being cut by a rusty piece of metal or playing around old tractors and car shells in a field, or metal toys left outside that turn to rust. It could be argued that displaying corrosion in architecture could produce this psychological effect, this induced déjà vu to evoke emotion from childhood.

Figure 9: 'Seen Better Days – Bodie Ghost Town' by Tom DiMatteo 2007[18]

3.4 Senses

A human's various senses are responsible for collecting information and contribute to our sensory awareness or perception and understanding of a situation.

Pallasmaa wrote about material choice and its impacts; 'Flatness of materials and surfaces, uniformity of illumination as well as the elimination of micro-climatic differences, further reinforce the tiresome and soporific uniformity of experience. The inclination of today's culture to standardise environmental conditions and make the environment entirely predictable is causing serious sensory impoverishment.'[9] The use of the corrosion process in buildings as a design tool would utilise many of the senses that would lie dormant in static architectural pieces. 'Abstraction and perfection transport us into the world of ideas, whereas matter, weathering and decay strengthen the experience of time, causality and reality.'[9] Possibilities might arise whereby the textures may develop a tactile quality in the production of the corrosion product will allow sight impaired people 'see' a building or maybe the perforation of a metallic panel may allow light, smells and air qualities such as humidity and the temperature of the external air to be experienced. The wonder generated in the incorporation of time into a building is that no two experiences of the same space will be the same due to the continuous process of change or transience of the phenomenology of the space.

4. CONCLUSIONS

The corrosion process of materials has a negative connotation from both a structural and aesthetic point of view which correlates with humanities obsession with the concept of new. It is important as humans that we continuously revisit and rethink the components of our world and look at already accepted concepts and notions in a different light. In Gerhard Auer's essay called 'Building Materials are Artificial by nature' he talks about how materials can develop additional meaning after their original intentions had been filled; 'A buildings material's purely useful role generally precedes its aesthetic ennoblement. Natural stones were first painted or clad with marble before their aesthetic beauty was recognised. Wood and brick were the building materials of the very poor before they were allowed to adopt the respectable symbolism of bourgeois uprightness. Steel and glass were first used in the construction of less-worth greenhouses and railway station halls before they were glorified in crystal palaces.'[19]

This evolution of the way humanity thinks about materials is the essence of what the application of the corrosion process in architecture is about. The changing of predominant, preconceived negative views on the destructive forces of corrosion and applying them in architecture in a constructive and positive manner, in a way that delivers meaning to the structure and provokes thought and interest, is the purpose of this paper.

It should also be noted that not only metallics can show the dynamic of time through constructive and controlled deterioration. There are many applications in many materials, which will be the subject of further thought and investigation, to develop with time. The exhibiting of these materials is important; showing the tectonics of a material, a buildings structure and elements of construction. The enablement of materials to be used in construction to show their material beauty provokes interest and allows a material to be displayed for its truth and honesty.

Architecture is usually understood as a visual syntax, but it can also be conceived through a sequence of human situations and encounters. Authentic architectural experiences derive from real or idealised bodily confrontations rather than visually observed entities. The visual image of a door is not an architectural image, for instance, whereas entering and exiting through a door are architectural experiences. Similarly, the window frame is not an architectural unit, whereas looking out through the window or daylight coming through it are authentic architectural encounters.[9] The use of the corrosion processes discussed is the scientific application of an idea to produce an architectural quality, whether it is the development of an image, the production of a finish or the perforation of metal to let light into a space over time. Due to the constant process of decay no single experience will be the same. The experiential applications of the destructive forces of corrosion used in a positive manner to add value to architecture are undeniable.

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Giles Harrison has recently completed his degree in Bachelor of Applied Science (Arch) and is currently completing his Masters of Architecture, studying full time at Curtin University, Western Australia. He holds the position of Project Coordinator at Extrin Consultants, a position he has held since 2008. Giles has only recently joined the corrosion and durability field having 2 years in the Corrosion Industry and 6 years in the Architectural Drafting profession.

Giles has developed a keen interest in utilising the science of corrosion in architecture to develop an aesthetic. Essentially his research has dealt with the corrosion process of metals and how this can be used to show the progress of time in architecture as well as the associated meanings, applications and implications of its use.

As a specialist qualified Corrosion Engineer, holding both a MSc and PhD in Corrosion Engineering, Dr. Peter Farinha has been involved in identification and problem solving of corrosion related issues in steel corrosion and reinforced concrete including inspection, identification, failure analysis, materials selections, coatings, specification and repair methodology for over 30 years.

He is a specialist in Microbiological Corrosion related issues, having gained his PhD in the corrosion of steel piling by sulphate reducing bacteria in ports and harbours in 1982.