Advanced Topics in the Science and Technology of Concrete
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Interview with Doctor Sergi

(Refer Slide Time: 00:11)

(Professor – Professor Conversation starts)

Doctor Radhakrishna: So welcome

(Refer Slide Time: 00:13)

Doctor George Sergi. So we today we have Doctor George Sergi from Vector Corrosion Technologies.

He is a pioneering figure in cathodic protection of concrete structures. Significant experience in this area of about 20 years, so it is our pleasure to, my pleasure to actually invite and have an interview with him, you know on what is the development, what have been happening in this area and what we should do in future to protect most of our concrete structures.

So welcome Sir, for...

Doctor George: Thank you, thank you very much

Doctor Radhakrishna: For your valuable time

Doctor George: Thank you for giving me an opportunity to talk to you.

Doctor Radhakrishna: So we all know that, you know that you have been developing many systems for cathodic protection of concrete structures.

Could you please, you know, tell something about how you started working in this area, or what motivated you to get into this industry like 30 years ago? At that time how was the industry and what made you to get into this and little story of early time...

Doctor George: Please thank you Sir, 30 years, basically it is actually nearly 40 years now

Doctor Radhakrishna: Ok. (laugh)

Doctor George: And yes, I mean it was kind of accident in a way because I completed my studies on metallurgy, material science and I finished the Master's degree on corrosion.

And out of the blue I got an invitation by one of the professors who were working on corrosion on steel and concrete about that time. And he asked me to whether I wanted to do piece of work or in as a research on galvanized steel.

And in concrete we have galvanized steel. Because galvanized steel is just coated with zinc on the steel and that gave me the opportunity to understand how the zinc works in a concrete environment and we were trying to see whether galvanized steel could last sufficiently in the concrete environment.

What we did find, by playing around the different solutions, different mixtures that as you increase the p H, zinc was corroding more and more. So that was the first lesson I have learnt that in fact zinc could be very, very active in very highly alkaline environment.

And subsequently again out of the blue came the idea that they wanted to use cathodic protection that was used in America, not fantastically successfully but there was a new process that was being adopted for, for steel reinforced concrete.

And there was a real need in the area that was, I was living in, near the University to carry out some trials to identify types of anoding material that could work for cathodic protection of reinforced concrete.

And I was just lucky to be in the right place at the right time. The trials were about 3 miles from my University so we became the main body of overlooking these trials and we did some experimental work also to learn about side effects of cathodic protection. So all that build up of knowledge obviously attracted me to...

Doctor Radhakrishna: To remain in that area

Doctor George: To remain in the area and just one thing led to the other. We had an invitation from a local company, a production company who were telling us that their Plaster of Paris were failing even though they were working so hard to improve the material. What is the reason and so on? And so we understood...

Doctor Radhakrishna: Halo effect…

Doctor George: The concept of the Halo effect, Halo effect and the incipient anode formation

Doctor Radhakrishna: Ok

Doctor George: And then we were asked to solve that problem. And the rest is history really, rest is rest.

Doctor Radhakrishna: Any other major milestones which like you know, in the developed because Vector has several products in the market.

Or not necessarily this particular company but there are several products in the market. So how different products evolved, you can give some light on that?

Doctor George: Yes I think, it all started with trial in the U K where they were desperate really to find some anode materials that will actually work and a lot other tried that and I would say that 80 percent of them had failed.

They were producing enough current that they were giving other problems like acidification around the surface of the concrete and of direct failure like some of the cement paint systems would flake off of the wall and at that time only two systems actually, stood out.

It was a particular paint system which is based on carbon and a mesh that was titanium based and was coated with mixed metal oxide to allow better conductivity.

But from there, of course once cathodic protection became established, many, many people got involved and research was carried out.

And I think one of the major things was invention of the discrete anodes which were then able to put into grill holes, into the concrete so structural elements were very difficult to get to, because they were very deep into the concrete.

Doctor Radhakrishna: So before that it was all surface applied system.

Doctor George: Yes, totally surface applied. But now they recognized that they have now been protecting some critical points, for example one of the critical elements in the

construction around the Midland Links as we call it, just the elevated sections of the highway that goes around the city.

One of the major concern is the half joint. And half joint is a very critical steel bar that goes across very close to where the joint is and that is hidden away inside the concrete. And if that fails the whole structure collapses. So how to protect that particular element? You can only do it by drilling a hole and getting close to it.

Doctor Radhakrishna: Ok

Doctor George: So that necessitated development of the...

Doctor Radhakrishna: How to get closer to the ribbon (07:37)

Doctor George: How to get closer to the ribbon (07:37)

Doctor Radhakrishna: To make it more effective in that way

Doctor George: Correct, yes.

Doctor Radhakrishna: I also know you have done a lot of lab research and product development, you know whenever we try to do something new to the market, there will always be some resistance.

Doctor George: Absolutely

Doctor Radhakrishna: (laugh) So what are the different types, because we are also like, you know in India this is something new to many of us, these technologies, many of the engineers do not know about this technology and we have lot of structures which are either experiencing corrosion but we do not know that.

So we are waiting, you know to see more corrosion related damage and issues like that, so but still there is a lot of resistance when it comes to a new technology to be implemented. So how, may be you might have also faced something similar and how you could actually overcome such scenario?

Doctor George: I think that is a very true case. In the U K everything goes through the Highways Agency or what is now called Highways England. And if they make a decision to use an assistance, they it comes to the market. Before that happens you would be lucky if you persuade 1 or 2 engineers to use it. Because they are all waiting for the Highways Agency

Doctor Radhakrishna: They were waiting for the course and the direction from the government

Doctor George: Correct

Doctor Radhakrishna: It has to be in some book

Doctor George: That is right

Doctor Radhakrishna: to be able to use

Doctor George: That is absolutely right. And then there was, I mean, the fact that they had a big problem with the Midland Links, meant that they had to do something about it, and they basically reached a stage where it was now, they had to do it now otherwise it would stop.

Having to demolish the construction and that would have cost huge amount of money. So maintaining those structures was so important to them that they were happy to carry out these trials

Doctor Radhakrishna: Ok

Doctor George: And that gave the opportunity for the cathodic industry to, protection industry to develop from that. Later on when we introduced galvanic anodes Highways Agency said they said they were not interested.

Doctor Radhakrishna: Ok, not interested

Doctor George: We already have a solution, why we should bother with anything else? And now was a very hard work to try and convince the Highways Agency to adopt galvanic anode.

And it probably took about 10 years for them to consider actually putting it in patch repairs, may be a good solution. And it took a lot of visits to Highways Agency and explaining and showing results and they had to wait for some results to (()) (10:34) unless I showed to you we had a 20 year history of galvanic anodes being...

Doctor Radhakrishna: So that is the same challenge which we also face when we try to suggest new ideas, they, we are asked to give data

Doctor George: Correct

Doctor Radhakrishna: And not short term laboratory data but the field, long term field data

Doctor George: Correct

Doctor Radhakrishna: So we may not have

Doctor George: I feel...

Doctor Radhakrishna: Not have it

Doctor George: Yeah. I think you could be at the better advantage than we were

Doctor Radhakrishna: Yes

Doctor George: Because there are results...

Doctor Radhakrishna: Now we have your results

Doctor George: You have the results available from U K, from other European countries and when you have that at hand, hopefully it would be a bit easier to persuade the powers-to-be, people who are making decisions that well, they are using it and it is good enough for them. Surely it can work for India as well.

Doctor Radhakrishna: Ok and now I know there were some companies in India also where they were having both, repair material wing and cathodic protection wing. But unfortunately there was a perception that these two wings are going to be competitors...

Doctor George: Right

Doctor Radhakrishna: you know the repair material industry and the cathodic protection industry, so what is your opinion on that?

Do they need to be, or are they really competitors or they are actually helping each other? In other words, if you have a structure which is repaired without cathodic protection system and repaired with cathodic protection system, the second case you may see that the repair is actually going to be durable.

But it is, many do not realize it and they look at it as a competitor and tell not to use cathodic protection. So what is your opinion on that? Are they really competitors or....?

Doctor George: They are absolutely...

Doctor Radhakrishna: they are helping each other?

Doctor George: Absolutely no competition because still people think patch repair is a patch repair. You could apply patch repair and it could last for a few years, not because of the materials part, but because of the Halo effect that I mentioned before.

Doctor Radhakrishna: Yes

Doctor George: You apply fresh repair to an area that you have taken away the old concrete, cleaned the steel, automatically you are making that the cathode of the system. And somewhere else there has to appear an anode to balance that.

And that tends to happen around the edges which is the nearest to the patch where there is probably still a little bit of contamination. Was not a problem beforehand because that patch was corroding so much it was kind of protecting the outside.

But now the roles are reversed. And therefore the corrosion will start from periphery. No matter how good you repair this, no matter how good your repair material is, you cannot avoid that....

Doctor Radhakrishna: Interface between the old and new concrete

Doctor George: Correct

Doctor Radhakrishna: Still there will be...

Doctor George: It does even have to be as a repair, you may want to construct another extension to your old structure, the same would apply there because my fresh steel....

Doctor Radhakrishna: In contact with the old...

Doctor George: Concrete, with contact with the old, and the same kind of effect will happen. So what the galvanic anodes would do, if you use galvanic anodes within the patch repair is prevent that problem.

So what is the issue? Your patch repair would look better. It would last longer. So this is the two should be working together, I believe.

Doctor Radhakrishna: Ok. Now one other question which we have is again, it is all about the perception; you know that people try to go borrow ideas from one industry to the other.

So like in this cathodic protection also people think that some of the codes which, existing codes they were originally made for steel structures or structures without concrete, you know or metallic structures.

Doctor George: Yeah

Doctor Radhakrishna: And we are adopting those criterion which are good for those structures, may be sometimes with aqueous environment but when it comes to concrete it is an all different ball game.

But still we try to use the same code. So what do you think that we, in the concrete industry should do to work on what, you know modifying the codes and making them very specific to the applications in concrete?

Doctor George: Well....

Doctor Radhakrishna: Different, you know what are the challenges or...

Doctor George: I think that is the process that is sort of going on in Europe and America with the European Standards and the main (()) (15:42) Standards which tries to concentrate on the specifics of steel reinforced concrete. Or in fact I think contains masonry as well but they have recognized that...

Doctor Radhakrishna: Steel versus a ceramic in concrete

Doctor George: Yeah. They have recognized that there is a difference between steel underground, for example and steel above ground structures. Specific code practice or standard that only deals with structures are exposed to the atmosphere...

Doctor Radhakrishna: Ok

Doctor George: So that is a specific condition, a specific way of looking at the problems that you will face if you try to apply cathodic protection. Biggest issues are resistivity of concrete, because it is above ground it can dry easily, it can get wet-dry cycles, you can get variations in current.

And other issues may be the type of anode that we use has got to be durable, it got to last 50 years, 100 years whatever the design life of the system might be.

And also the spacing, spacing is a big difference between what you will get in the structure above ground and structure below ground. Below ground because of the low resistivity you can space anodes widely apart and in fact in pipeline and cathodic protection systems we are talking about several, even kilometers...

Doctor Radhakrishna: Kilometers

Doctor George: Whereas anodes are spaced out quite widely yet they still protect the structure because there is such a low resistivity, current can flow everywhere. Cannot do that in concrete, spacing really needs to be just a half a meter in most cases, or even less depending on the resistivity of the concrete, because the flow of the current becomes much, much more difficult.

Doctor Radhakrishna: That is one area where we still do not have a rational design methodology considering these different factors and then come up with design like design methodology for cathodic protection system for concrete structures, do we have?

Doctor George: Yes. I was talking about the European Standard which is....

Doctor Radhakrishna: About the concrete

Doctor George: It has been in existence but there is now a review over the next year and half, and that it is necessary to have these reviews and it has been happening every couple of years so far. But we still have not got it right and the issues are different people have different...

Doctor Radhakrishna: Viewpoint

Doctor George: Viewpoints and it is so hard to get a common standpoint and, but even so, those standards are actually quite good at the moment and I would recommend that, that as the starting point, you go with what is already available in those standards

Doctor Radhakrishna: Ok, now coming to this, when we talked about concrete, reinforced, conventionally reinforced concrete structure, now there is a new set of pre-stressed concrete.

Lot of new structures are built with pre-stressed concrete elements and there if there is corrosion, recently we did some study we found that, you know corrosion will happen but it will be very, it will not show stains on the concrete surface, rusted stains or it is longer to detect.

So you will think that nothing wrong is going on but it is actually corroding, so...

Doctor George: Hidden

Doctor Radhakrishna: Corrosion, so hidden corrosion is happening. So in such cases, for pre-stressed concrete, do you have, do you think that cathodic protection will be a good thing to do, especially for new structures so that we can ensure that they do not corrode? Or what are the challenges when we try to do that?

Doctor George: I think there are many challenges.

Doctor Radhakrishna: Yes

Doctor George: You cannot just take the one and move it on to the other.

Doctor Radhakrishna: Yes

Doctor George: Unfortunately in a lot of cases you will have to the sheath that surrounds the strands, for example and you cannot pass current through the sheath. So, so future generations, if we start thinking about that, then do we make that sheath conductive perhaps?

Do we allow the current to go through or do we pre-design so that this is an anode material or the sheath itself could be anode material. So we can subsequently if we need to, even from the beginning apply current to the...

Doctor Radhakrishna: When you said sheath itself could be anodic material, earlier we used to have G I pipes or galvanized iron pipes as the ducts...

Doctor George: Yeah but...

Doctor Radhakrishna: Now we use plastic, H D P E pipes

Doctor George: Correct, correct and obviously that is technically we will be backwards because there is no way. We can neither pass current through it....

Doctor Radhakrishna: So are you suggesting that we should actually go for metallic ducts and not the plastic ducts?

Doctor George: It is something that we should be considering. I think we have, we need to have a long term view of all these things and look at what the problem has been so far. Biggest problem was that, as you explained is corrosion happening inside and we do not know...

Doctor Radhakrishna: We do not know that, yeah

Doctor George: You have no idea, you cannot see, it is not staining so even if there is lot of corrosion the only way you find out is when the thing breaks

Doctor Radhakrishna: They snap

Doctor George: They snap (laugh) and it is too late

Doctor Radhakrishna: It is too late

Doctor George: So you know people are finding such a lot of difficulty now in trying to stop that corrosion and really the only way is if you try and insert some non-corrosive material or some protective material through the strands themselves, you have to inject from one end and hope that it covers the steel reinforcement and at least hold it in that position where there is no further corrosion.

So to apply cathodic protection outside is almost impossible, unless the strands are exposed inside the concrete. Then you can apply the low level of cathodic protection because the other element of, I can say dispute, it is not really a dispute, if you introduce hydrogen evolution on the steel surface which can happen if the potential of the steel goes below minus 850 by, one (()) (22:20) is the low oxygen availability or whatever, that can cause hydrogen embrittlement.

And it is a case for galvanic anodes, a good case for galvanic anodes because they would never allow potential drop that low but it can only work if the sheaths are not surrounded by a non-conductive material.

So I think looking into the future, it is just the suggestion obviously, why not make the sheaths out of material where I can apply current...

Doctor Radhakrishna: Directly to the...

Doctor George: Directly to the...

Doctor Radhakrishna: And this is very close to the strand

Doctor George: It is very close; it is going to be a very low current density

Doctor Radhakrishna: Ok

Doctor George: Because of the low resistivity

Doctor Radhakrishna: That is a nice idea to try it out (laugh)

Doctor George: Idea for you to work on this

Doctor Radhakrishna: To work on

Doctor George: Research (laugh)

Doctor Radhakrishna: So what other things do you think we should we work on, I mean for the next generation engineers to work on, what is remaining …?

Doctor George: I think the Standard itself is in need of improving, in my opinion. It is not a common opinion so I may have difficulty (laugh) in trying to persuade the others in doing that. My main issue is the 100 milli Volt depolarization criteria which everybody seems to want to use.

It has been in the Standards for number of years now. And it is both in the European and the main Standard. For a 100 milli Volt polarization we have found that it is Ok, it is not totally meaningless. It means that you are reducing the corrosion rate by possibly a factor of 10 which is a very good start.

And, but often the case is with, strictly with galvanic anodes where you cannot even, cannot get 100 milli Volts polarization or suddenly you cannot get it all the time. You can get in

some periods, sometimes you do not. And that almost disqualifies the galvanic anode cathodic protection from being recognized as a cathodic protection...

Doctor Radhakrishna: So only impressed current technique will probably work

Doctor George: Yeah, so in that case impressed current techniques can do it. They contain all the current, but do you need that extra current? We found that with lower than a 100 milli Volt depolarization you can retain the corrosion in a lot of cases.

Ok sometimes you may need to go to impressed current cathodic protection for different considerations but if it is a small area, particularly by smaller, it could be up to 10 meter square, 20 meter square, actually going through the cost of installing impressed current cathodic protection, it is really not, not a good suggestion for the client.

Doctor Radhakrishna: Ok

Doctor George: Because they get this initial cost of having to produce the whole system including the...

Doctor Radhakrishna: And then monitoring, making sure that I will...

Doctor George: They have to achieve this 100 milli Volt polarization

Doctor Radhakrishna: And also ensuring the system actually, vandalism and many other

Doctor George: For sure...

Doctor Radhakrishna: onsite problems...

Doctor George: Because there are lots of outside wires

Doctor Radhakrishna: Yes

Doctor George: But in those sort of areas they can easily be coped with galvanic anodes provided you design for the right parameters, the right spacing to achieve the current density that we require. And depolarization may not be 100 milli Volts, may be 80 and sometimes 120, sometimes 60.

Does that mean that the thing is not working? No. We have found that, in fact, because of the variation of the current the fact that sometimes you get the lower depolarization, what that means is that at that particular time the current density was a bit lower because the concrete was a bit drier.

And if the concrete is a bit drier, steel is not corroding that much.

Doctor Radhakrishna: Yeah

Doctor George: So it does not need so much current. So there is a lot to be learnt from the...

Doctor Radhakrishna: Multiple factors have to be brought in before we decide on this criteria.

Doctor George: Absolutely. And I think that using the depolarization in a different way would help us tremendously. We can use the combination of depolarization and polarized potential and current density that gives you an idea what the corrosion current density,

So how much steel is corroding and if you use it in combination with the polarized potential it also tells you how much corrosion is going on. That should be a better criteria, better set of criteria than just a 100 milli Volt depolarization.

Doctor Radhakrishna: And especially with this new type of concretes, like high resistive, highly resistive concrete and low alkali concrete so you may have different challenges also to do research on

Doctor George: I believe so. I think it is one thing that we have so taken for granted is that all the concrete is made of Portland cement

And it has got lots of calcium hydroxide which saturates the solution and keeps the p H at the certain minimum level and acts as a buffer in actual fact to protect the steel reinforcement, to produce the oxide film, protective oxide film.

But this is now a different way of we should be looking at it because that calcium hydroxide is gradually being removed because of these new materials are being used, even using substitute materials like slag or micro silica. I know that if you had enough micro silica you can drop the p H down to even 11. And that is totally different....

Doctor Radhakrishna: Concrete

Doctor George: environment for the, for steel reinforcement. So the corrosivity would increase with the, with these types of cement. We need to be looking into that early on.

Because what I imagine would happen is that we satisfy ourselves that these concretes are durable and strong and we start using them and then we find that 5 years later the steel is corroding.

Doctor Radhakrishna: Yeah (laugh)

Doctor George: And we start asking the questions then.

Doctor Radhakrishna: (laugh)

Doctor George: You know, let us start asking the questions now. And try and design accordingly.

Doctor Radhakrishna: So with that I think the main ideas we have to actually start having a corrosion management team in most of the construction projects

Doctor George: I believe so

Doctor Radhakrishna: which will probably help us in preventing corrosion from happening rather than waiting and doing a corrective repair or maintenance practice

Doctor George: Absolutely right

Doctor Radhakrishna: So I think cathodic protection will be one way of controlling corrosion in concrete structures, and like you said you know we still have a long way to modify the system for the new type of concretes and work on code, codes mainly adopting the existing codes for, you know concrete, application to concrete structures or conventional and pre-stressed. These are the challenges I think...

Doctor George: Yes, sure.

Doctor Radhakrishna: we have ahead

Doctor George: Sure, sure, quite a few challenges. There is still lot of research to do.

Doctor Radhakrishna: Lot of research to be done

Doctor George: (laugh)

Doctor Radhakrishna: Thank you very much

Doctor George: It is a pleasure

Doctor Radhakrishna: For your valuable time

Doctor George: Thank you very much for having me here and feeling absolutely

Doctor Radhakrishna: I think, whichever is your times (laugh)

Doctor George: I have as well because like I said to you privately, I think this is fantastic campus and all your students are really lucky to be working here, fantastic environment for the brain to be working beautifully

Doctor Radhakrishna: Thanks to IIT Madras for providing us that environment. Thank you.

(Professor – Professor Conversation ends)