Interview with Prof. Viacheslav Troian, Kyiv National University of Construction and Architecture, and Prof. Robert Flatt, ETH Zurich

Prof. Viacheslav Troian, Kyiv National University of Construction and Architecture, and Prof. Robert Flatt, ETH Zurich, are co-authors, together with V. Gots, Kyiv National University of Construction and Architecture, E. Keita, Gustave Eiffel University, N. Roussel, Gustave Eiffel University, and U. Angst, ETH Zurich, of the paper *Challenges in material recycling for postwar reconstruction*, published by RILEM Technical Letters in December 2022. This interview took place in December 2023, one year after the publication of the paper.

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Dr Daniela Ciancio - RILEM Implementation Manager (RIM): Good morning and thank you for joining me today. Dec 2022-Dec 2023… What happened during these last 12 months?

Prof. Viacheslav Troian (Viacheslav): Well…after this paper, we received a lot of different propositions, like, invitations from the Swiss TV (*Editor's note: the link is to a video in German*), the German radio, etc… now we have these recordings in German language where Robert, Ueli Angst and I explain these topics. After the paper came out, we started promoting this topic around Europe. For instance, I gave an online joint presentation with colleagues from Poland (*Editor's note: the link is to a video in Polish/Ukrainian*), where they experienced massive destruction during World War 2 and need for reconstruction after it. I was also invited to talk at the Ukraine Green Recovery Conference, in Vilnius, Lithuania. It was interesting because there were many Ukraine officials talking about the reconstruction of Ukraine. I presented our work, explained this technology and how we see recycling being used in Ukraine. It raised a lot of interest and helped achieve my goal of bringing this message to Ukrainian people, industry representatives, governors and politicians. I additionally gained some contacts with Ukrainians concrete suppliers and concrete plants…

RIM: … and this takes me exactly to my next question: beside the academic interest in your paper, have you received any feedback from the industry? Any action in that area that was triggered by your paper?

Viacheslav: Yes! I can see how the information in the paper has moved from the academic level to the industry production level. So, in Ukraine, we recycled construction waste before the war, but this material was not used for civil buildings, only for roads. Now, I see companies in Ukraine that are starting to recycle old concrete and produce recycled concrete for civil buildings. For example, the French company Neo-Eco already has an ongoing pilot project of housing reconstruction near Kyiv with a budget of 45 million euros. I met them at the conference in Vilnius and we might try to do something together in the future.

Prof. Robert Flatt (Robert): Let me take a step back to the paper. You know the topic of concrete recycling has been worked on a lot. There's a lot of data, there are some guidelines, but the question in the case of Ukraine, and other places in the world that unfortunately need reconstruction, is

“what are the overarching simplest conceptual messages that one can give to help people make good-enough concrete with local recycling of aggregates?”. So, to me, this paper can be viewed as very academic, or it can be viewed as very practical, but it's still very conceptual and on a meta level. It aims at boiling down existing knowledge into simple and usable information for that context of reconstruction. This is not a topic that we were working on before, but we did a lot of work that is highly relevant to recycling concrete; so we felt that we could put together that conceptual statement. I would say that since then, the following things have also happened: 1) we started to do experimental work on some of the questions that our paper pinpointed as important and 2) a second paper on this matter has just been accepted with minor corrections in Materials and Structures (*Editor’s note: Troian, V., Gots, V., Flatt, R.J. et al. Rehabilitating instead of rebuilding aged or damaged pre-fabricated concrete buildings for reducing CO2 emissions: the case of Ukraine. Mater Struct 57, 14 (2024)*)…

Viacheslav: … this recent paper is not about recycling but about buildings which could be repaired rather than demolished in Ukraine…

Robert: … indeed, and the idea “there is more that can be maintained even if damaged”. But apart from that, we've also looked at questions of rheology and how to process the recycled materials. Two bachelor thesis students signed up for projects with Viacheslav, and there are two others next semester, so there is certainly a clear interest from the side of students in this topic and cause. And then there's been also a lot of interest from practise. The clue is finding the balance between what we can really do on this topic at a university, while aiming at sharing knowledge and getting information from practise. In essence, there are 2 main contributions: university settings on the one hand, which is, let's say, meta to conceptual level: What do we know that can help do things better? How do we transfer that to the practise? How do we communicate those simple things effectively? Knowing where the problems are, which part of the problems can be partly resolved by the type of work that we can do in a university? And then there are some more specific questions we can address and bring answers, which again we try to distil into simple usable propositions. Other issues then require, you know, empirical work, systematic testing, practise experience, which we don't have the access to or really the expertise but we're trying to contribute to the overall field, I guess.

RIM: In the paper you present high-tech recycling processes that are energy-consuming, require a certain level of know-how, and have facilities that are not cheap. These processes are unlikely be used in Ukraine.

Viacheslav: In the paper we discuss different technologies proposed to the recycling industry. This may be equipment for basic concrete recycling or high-tech in which case the final recycled material looks like “normal” aggregates. However, my expertise and that of Robert, lies not in the process of recycling concrete aggregates, but rather studying the performance of new concrete made of this. Our statement is that, in the case of Ukraine, we can have recycled aggregates obtained with less expensive processes, or high-tech and easier to use ones, but with a price that would be several times more than “normal” aggregates. I think that this would not work in Ukraine. So we work with this type of basic grade recycled aggregates. Possible problems with these may be presence of chloride, sulphates from gypsum-based products. Most problematic however is the loss of fluidity, and there, we have means of acting based on our knowledge about concrete technology, use of admixtures, use of different cement types, etc… I think that this should allow us to make good enough concrete with ordinary recycling, which is important because the high-tech recycling processes existing in Europe would economically not be efficient in Ukraine.

RIM: So, you still make a very good concrete even though the initial material is not as clean as it is in other cases.

Robert: The question of the sorting of the materials is, of course, an important one. And that can be done to different levels. I would say that it can be done with low budgets at a good-enough level, but it can be done much better with automated plants, etc…, which are not realistic in the case of Ukraine and other places with similar challenges. The less perfect that process is, the more problems you have with rheology, and in practise, if people don't have good enough fluidity for concrete, they're going to add water just before casting it. As we all know, doing that is very detrimental to the final properties. Indeed, there is a high risk that the added water exceeds the one absorbed by the aggregates, which increases the water to cement ratio in the paste. This causes the hardened material to have a higher porosity that results in both lower strength and durability. That variability is a great threat. So, you know, if the water that can be absorbed by the aggregates is provided earlier, letting them absorb it, and then completing the mix design, this will leave you with rheological properties that are much more stable over time. You eliminate the randomness and risk of errors leading to bad concrete. **To me pre-wetting is really "the thing"**! The big challenge, I would say for ordinary recycling, is that somehow people want to save the time from pre-wetting the aggregates. And then they use different admixtures, and they try to improve the recycling to make life a little bit easier for the clients. What they actually do in order to control the rheology of recycled concrete is a bit dark arts, and it's not always working, as it depends on multiple factors. The stars are not always aligned! The problem can be approached as follows. In essence, one thing you can try to do is to have a superplasticizer which increases its absorption over time to compensate for the fluidity loss resulting from water going into the aggregates. The mechanism involved here, that is the role of water and superplasticizers on rheology, are completely disconnected processes: one is purely physical, the other is chemical. It relies on the pH to change the ionicity of the superplasticizer over time. Further to this, the superplasticizer is mainly sensitive to the specific surface, while water changes the volume fraction of solids. So, the odds about getting these unrelated processes to compensate for each other is relatively low. It's not impossible, but there's no clear methods on how to attack that problem in a structured way. So, **the classification of the aggregates needs to be done to some extent: yes! The realistic extent to which it can be done means you'll have more or less problems in terms of rheology, which will translate into issues of variable performance in strength and in durability**. I guess that really is the core message we wanted to get through.

RIM: This is the message that Viacheslav is communicating through radio and TV interviews, as I don't think that regular concrete practitioners read *RILEM Technical Letters*.

Robert: The fact that *RILEM Technical Letters* is Open Access was a clear motivation to publish in that journal. At the time Swiss universities still had a deal with multiple publishers for open access, but for us it was also important that it was a RILEM publication. RILEM can help such work become more visible and accessible. That to us was very important.

RIM: Would you like to add an extra message that may not be in the paper, or it might have not come out as clear as you wanted?

Viacheslav: I could maybe have a message/advice for Ukrainian concrete producers. Many people in Ukraine think that concrete recycling is when we have a big pile of different wastes that we put in one magic machine and, as a result, we have a good recycled material. But in reality, we need to do some pre-sorting. The more the better, but that means increased costs. Then, as Robert said, using basic equipment or high-tech equipment will influence the final result, but pre-sorting is a key step. Finding the right level of that pre-sorting will vary, but should not be completely overlooked either. **In**

the case Ukraine, we see as parts of destroyed buildings, big blocks of concrete panels, slabs, walls, etc... My main message for producers in Ukraine is "use these big blocks". This is a piece of advice that comes from large recycling companies in Switzerland. Big blocks are easier to spot, you can check their strength, check if they contain different contaminants, you can clean them and by doing so influence the final result of the recycled material.

RIM: Anything to add, Robert?

Robert: Yes, the quote that I use in my lectures and that comes from Adam Neville. He stated something like "*the components of good concrete are very simple: cement, sand, aggregates, water, and some admixtures. The ingredients of bad concrete are essentially the same. The difference is the know-how*". I would add that the same holds for recycled concrete. I also think that what lacked maybe a bit in our RTL paper is this: we're on the road to conceptualise it better, and we tried to boil down to the simplest learnings to do good-enough or improved-quality concrete under challenging conditions. I think we could have reiterated a better, more structured, simple kind-of-take-home chart that probably adds something with respect to what existing norms propose.

RIM: Viacheslav, Robert, thank you very much for your time today!