International Scientific Journal of Civil and Infrastructure Engineering (ISJCIE), May 2023 Vol.1, Issue1, pp.46-58, ISSN: 2981-8168 (Online), Australia, DOI: https://doi.org/10.56601/ISJCIE
Infrastructure, Construction, Concrete, Geotechnic, Earthquake, Environment.

Numerical and Experimental Study on a Creative Concrete Pressure Reduction System (CPRS)

Saeed Nemati*, Western Sydney University, Australia
Yahya Aliabadizadeh, University of Maryland, College Park, USA
Farzad Yaghmaei, Almasaze, UAE

*Corresponding Author, Nematiuts@gmail.com, Received: Jan 2023, Accepted: March 2023

ABSTRACT: The lateral pressure exerted on concrete structures formworks is influenced by various factors, including the aggregate content and size, water-to-cement ratio (w/c), type and amount of cement, presence of silica fume, fly ash, slag, ground limestone filler, type and quantity of superplasticizer, configuration of reinforcement steel bars, rate and method of placement, concrete temperature, ambient conditions, set time of concrete, and the dimensions, type, rigidity, and roughness of the formwork. It can be challenging, and sometimes impossible, to simultaneously control all these parameters. This research introduces an innovative system called the Concrete Pressure Reduction System (CPRS), which incorporates sacrificial perforated sheets. The CPRS effectively manages the lateral pressure exerted by the concrete and mitigates excessive pressure on the formwork. Numerical modeling demonstrated that the utilization of this system can reduce the maximum principal stress, maximum shear stress, and maximum deformation by a minimum of approximately 27%, 30%, and 25%, respectively. Deformation obtained from parametric studies were verified through experimental tests, which displayed reasonable agreement with the outcomes of the study.

Keywords: Concrete Pressure Reduction System (CPRS), sacrificial perforated sheets, formwork.

1. Introduction

During the construction of concrete structures, it is crucial to design formworks that can withstand both the ultimate and serviceability limit states. Various loads, including wind, equipment/construction loads, snow, dead and live loads, as well as the lateral pressure exerted by the filling material, must be considered. For evaluation of lateral pressure, some factors must be checked. These factors can be summarized as follows:

- Materials (aggregate content and size, w/c, cement type and content, silica fume, fly ash, slag, ground limestone filler, superplasticizer type, and content)
- Placement Conditions (placement rate, placement method, the temperature of the concrete, temperature of the ambient, set time of concrete)
- Formwork Characteristics (dimensions, type, rigidity, and roughness)
- Reinforcement steel bars configuration

2. Research History

In general, research indicates that increasing the content and size of aggregates tends to result in a lower initial lateral pressure in concrete structures. In the context of highly flowable mixtures, a study conducted by Assaad et al. (2005) revealed that an increase in the volume of coarse aggregates led to a reduction in lateral pressure and an accelerated rate of pressure drop after casting. Increasing the w/c or/and superplasticizer content increases the lateral pressure. It is also shown that addition of Supplementary Cementitious Materials (SCM), such as fly ash (Gardner, 1984), silica fume or granulated blast-furnace slag (ASTM C989, 2014) affect the lateral pressure and more specifically its rate of decay (Khayat et al., 2007). In fact, mixtures with higher cement content develop greater lateral pressure (Ritchie, 1962). Amziane et al. (2000) reported that the use of a discontinuously-graded aggregate with Maximum Size of Aggregate (MSA) of 30mm can lead to higher lateral pressure for conventional vibrated concrete than a continuously-graded aggregate. Ore et al. (1968) reported that the effect of incorporating a water-reducing or set-retarding agent has limited influence on formwork pressure. Also, the effect of adding HRWRA (High-Range Water-Reducing Admixture) to enhance workability increased formwork pressure (Gardner, 1984). Ruiz-Ripoll et al. (2014) have studied the effect of mix design on fresh SCC (Self Consolidating /Compacting Concrete) on formwork pressure. Also. Perrot et al. (2009) studied reinforcement steel bars configuration on the applied lateral pressure of concrete on formworks. On the other hand, concrete pumped into the formwork from its bottom exhibits higher pressures than that placed from above. McCarthy et al. (2012) have shown that maximum concrete pressures with SCC are slightly lower than the full liquid head at any rates of rising in columns and walls. Base-to-top pouring may reduce the effects of impact pressure, as concrete entering formwork is absorbed into the body of the material (Johnston, 2010). The higher initial temperature of the concrete and/or the ambient temperature, will provide the higher lateral pressure and subsequently, a higher rate of pressure decay is recorded (Roby, 1935). In addition, after placement, mixtures with longer setting times display longer lateral pressure cancellation time (Khayat et al., 2007). In most studies, the pressure can be found to decrease slowly before dropping to zero approximately 3h after casting (Khayat et al., 2007). Several studies have established that the rate of casting could have marked effect on formwork pressure (Vanhove et al., 2001, Khayat et al. 2002, Leemann et al. 2003, Assaad 2004, Fedroff et al., 2004, Beitzel et al., 2004, Billberg 2003 and Tejeda-Dominguez et al. 2005). When the casting rate is so fast, formwork pressure could well reach hydrostatic pressure. For SCC placed at relatively moderate-to-high casting rates, Assaad et al. (2006) found the decrease in casting rate from 25 to 5 m/h can reduce the maximum initial pressure by 15%; however, no significant effect was noted on the rate of pressure drop with time. The casting interruption of 10 or 20 min between subsequent lifts at the middle of the placement was reported to lead to a considerable reduction in formwork pressure. Wolfgang et al. (2003) conducted such an investigation on a model wall. As expected, the decrease rate of placement resulted in lower lateral pressure for either the bucket and bottom injection placement methods. Rodin (1952) showed that smaller cross-sections exhibit lower maximum pressure. Gardner (1984) demonstrated that an increase in the formwork dimension will create a larger lateral pressure. Research also has shown that the type of formwork has an effect on formwork pressure. Specifically, rigid and smooth formwork materials result in higher lateral pressure and a lower rate of pressure drop after placement. The roughness of the forms also plays a role due to the dynamic friction that develops upon concrete placement (Djelal, 2001; Djelal et al. 2004, Vanhove et al. 2000). It was shown that the application of demoulding agents, such as oil, to the formwork, can decrease friction and lead to an increase in lateral pressure (Khayat et al., 2007). On the other hand, Khayat et al. (2005) have shown that the scale effect has an influence on the rate of drop in lateral pressure with time. Arslan et al. (2005) and similarly, Tejeda-Dominguez et al. (2005) have shown the decrease in pressure after casting was dependant on the forming material.

According to above-mentioned studies, there have been several theoretical models to predict formwork pressure, including several input parameters such as rate of casting, vibration system, setting time, consistency, form permeability and surface texture, form dimensions, coarse aggregate specification, the temperature and concrete unit weight (Proske et al., 2007). In addition to known models such as IS's model and CAN/CSA model, the most famous of these models are Omran model (Omran et al., 2013), McCarthy model (McCarthy et al., 2012), Models of German Standard (DIN 18218, 2010), Puente model (Puente et al., 2010), Proske model (Proske et al., 2010, 2014), Model of JGJ 162-2008 (Puente et al., 2010), Gregori model (Gregori et al., 2008), Graubner and Proske model (Graubner et al., 2005, 2008), Khayat and Assaad model (Assaad et al., 2006), Roussel and Ovarlez model (Roussel et al., 2005), Vanhove model (Vanhove et al., 2004), ACI model (ACI 347-04, 2004), Model of TGL 33421/01 (Puente et al., 2010), CEB-FIP model, Yu model (Yu, 2000), New Delhi model (Puente et al., 2010), CIRIA model (CIRIA, 1985), Models of French Standard (NF P93-350, 1995) and Tah and Price model (Tah and Price, 1991). Above-mentioned studies and many others in the literature have been the bases of several codes for the general design of formwork as shown in Table 1.

Table 1 Most common standards and regulation for formwork general design

Region	Regulated in	Formulated in	Notes and References
The European Union	EN12812:2008 ''Falsework Performance Requirements and General Design''	The European Committee for Standardization (CEN/TC 53 ''Temporary works equipment'') EN13670:2011 ''Execution of Concrete Structures''	
	Construction Industry Research and Information Association (CIRIA)		For the highly workable concrete, hydrostatic form pressure over the total formwork height must be assumed (Proske et al., 2014)
	DIN18218: 2010-01		For the highly workable concrete, hydrostatic form pressure over the total formwork height must be assumed (Proske et al., 2014) and for the design of the formwork, the bilinear pressure distribution is employed (Figure 2-14)
	CIB-CEB-FIP		For the highly workable concrete, hydrostatic form pressure over the total formwork height must be assumed (Proske et al., 2014)

	The European Federation of Producers and Contractors of Specialist Products for Structures (EFNARC)		Forms higher than 3m are designed for full hydrostatic head (EFNARC, 2002)
USA	American Concrete Institute (ACI)	ACI Committee 347 (2004) (ACI 347-04) and SP-4 (2014) ‘‘Formwork for Concrete’’	The lateral pressure diagram of concrete is assumed to be trapezoidal in shape (Figure 2-13) (SP-4(14), 2014). The significant variables considered in the ACI recommendations are the rate and method of placement, consistency of concrete, coarse aggregate concentration, aggregate nominal size, concrete temperature, smoothness and permeability of the formwork material, size and shape of the formwork, consolidation method, pore-water pressure, content and type of cement, as well as the depth of the concrete placement, or concrete head (Proske et al., 2014).
	Occupational Safety and Health Administration (OSHA)		(Nawy, 2008)
	American National Standards Institute (ANSI)		(Nawy, 2008)
	Scaffolding, Shoring and Forming Institute (SSFI)		(Nawy, 2008)
	American Society of Civil Engineering (ASCE)		(Nawy, 2008)
	Formwork Suppliers (FS)		(Nawy, 2008)
CANADA	Canadian Standards Association (CSA)	CSA S269.3 ‘‘Concrete Formwork’’	Unless the rate of placement can be controlled to a design specified rate, column forms shall be designed for full hydrostatic pressure
	Canadian Standards Association (CSA)	CSA S269.1 ‘‘Falsework for Construction Purposes’’	Unless the rate of placement can be controlled to a design specified rate, column forms shall be designed for full hydrostatic pressure
	Canadian Standards Association (CSA)	CSA S269-2012 (last version)	It considered the same provisions and language described by the ACI 347-12 for determining the formwork pressure of SCC (Khayat et al., 2011)
Australia	AS3610.1 (2010) “Formwork for concrete”	AS3600 (2009) “Concrete structures”	

3. System Configuration

As can be seen in Figure 1, this system consists of two sacrificial perforated sheets which are connected to each other using some ties. Sacrificial sheets are located between steel bars and the internal surface of the formwork. This system bears the lateral pressure of concrete and prevents a significant pressure on the formwork. The dimensions of the sheets, the diameter of the holes and their arrangement are completely optional. But, any change in any of these parameters can change the performance of the system. The material of these sheets should be such that they do not react negatively with the concrete and at the same time, they must have the necessary resistance.

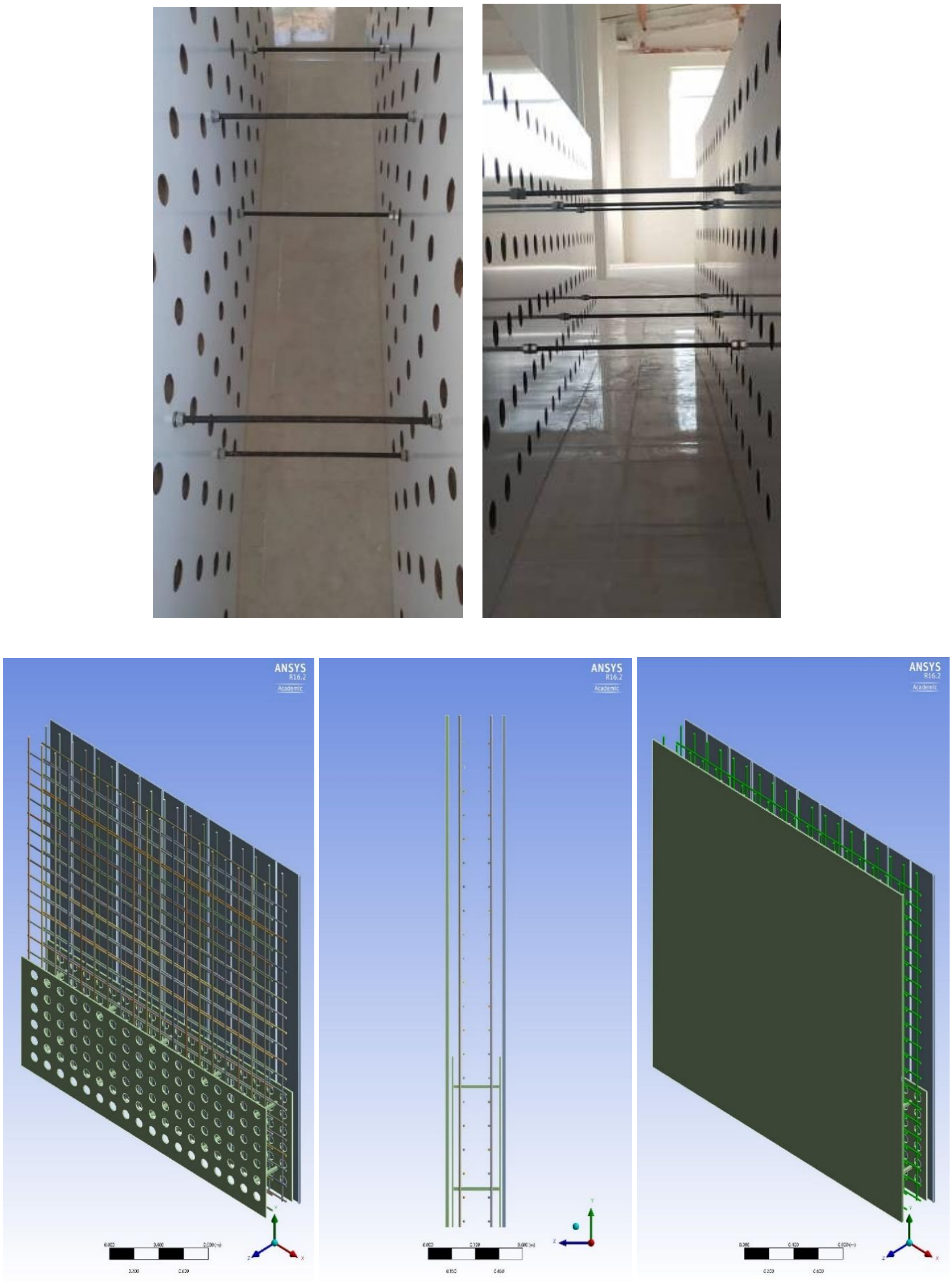

Fig.1 The general configuration of presented concrete pressure reduction system (CPRS)

4. Numerical Study

In this study, the PVC perforated plates are selected as sacrificial sheets. The internal width and the height of the formwork are 400 mm and 2,500 mm respectively. The material of the formwork is PVC with a thickness of 4 mm. The formwork has been assumed fixed in the bottom level (at y = 0). The thickness of sacrificial sheets are 3 mm and their height is 1,000 mm too. The diameter of the holes is 20 mm. The rate of the holes to the whole surface of the sheets is 0.3 too. The diameter of cylindrical ties is 10 mm and the distance between them is 700 mm. The used concrete has been modelled as a viscoelastic, homogeneous, and isotropic filler with a density of 2450 kg/m3. Figure 2 shows the distribution of the principal stress the shear stress in the formwork. As can be seen, the maximum principal stress and the maximum shear stress in the formwork are 22.88 MPa and 2.68 MPa respectively. These stresses are created adjacent to the supports.

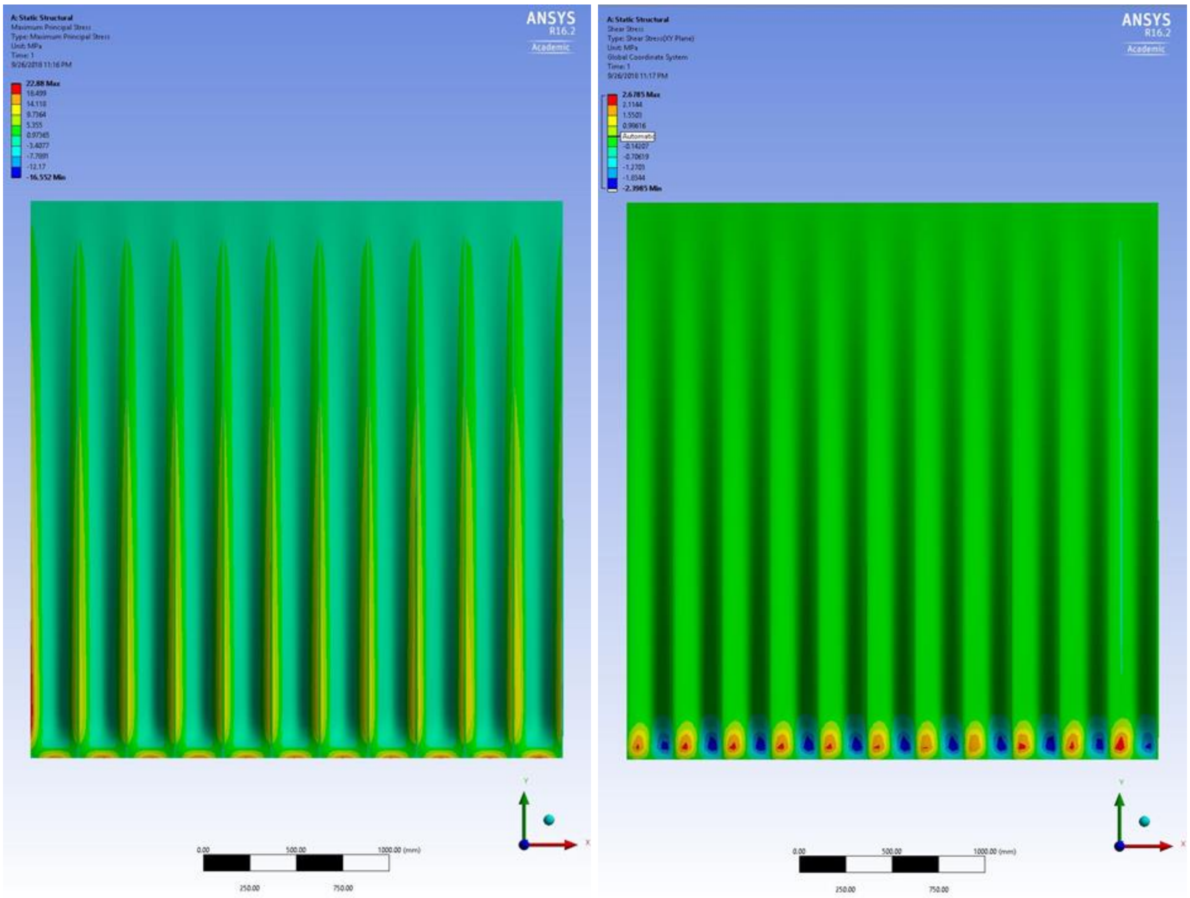

Fig.2 Principal stress (left) and shear stress (right) distribution in the simple formwork

Then the concrete pressure reduction system (CPRS) was added to the model. Figure 3 shows the distribution of the principal stress the shear stress in the sacrificial sheets. As can be seen, the maximum principal stress and the maximum shear stress in the formwork are about 150 MPa and 36.7 MPa respectively. These stresses are created in the location of the ties.

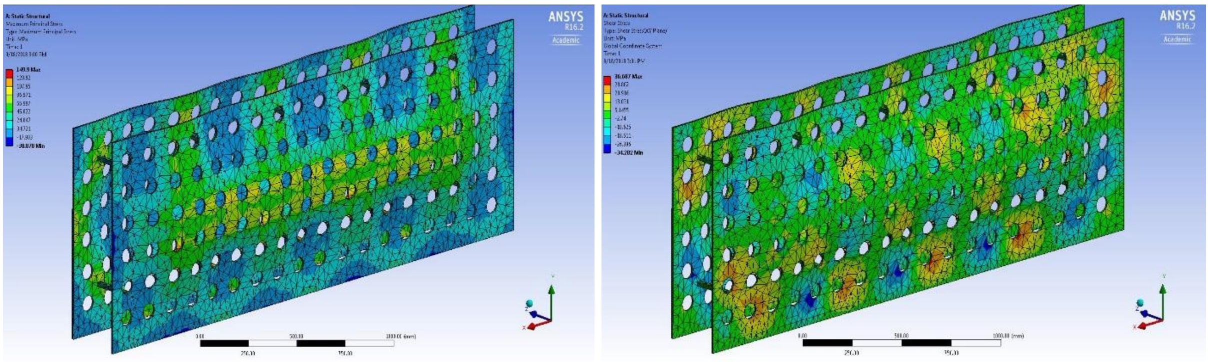

Fig.3 Principal stress (left) and Shear stress (right) of the sacrificial sheets

The deformation pattern of the sacrificial sheets is illustrated in Figure 4. As can be seen, the maximum deformation of the formwork is about 3 mm. This deformation is created in the middle of the locations of the ties.

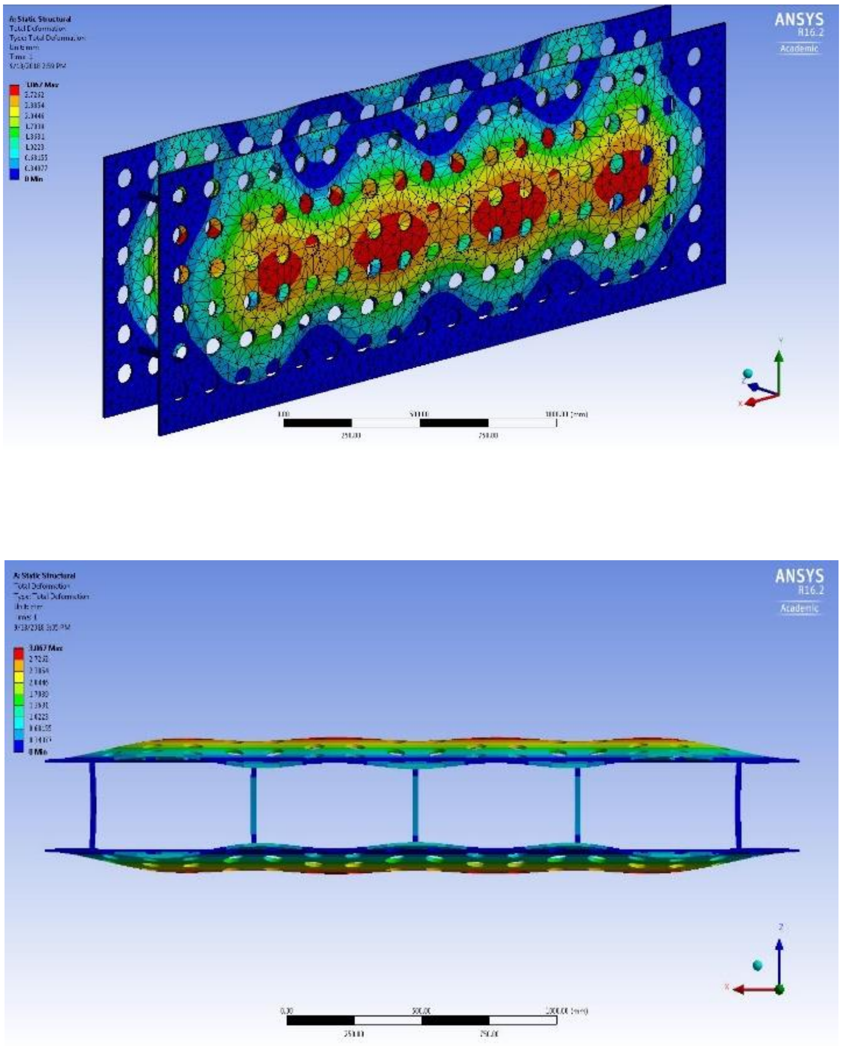

Fig.4 Deformation of the sacrificial sheets

Figure 5 shows the distribution of the principal stress the shear stress in the formwork after using the CPRS. As can be seen, the maximum principal stress and the maximum shear stress in the formwork are reduced to 16.7 MPa and 1.87 MPa respectively in compare with 22.88 MPa and 2.68 MPa regarding simple formwork. These stresses are created adjacent to the supports too.

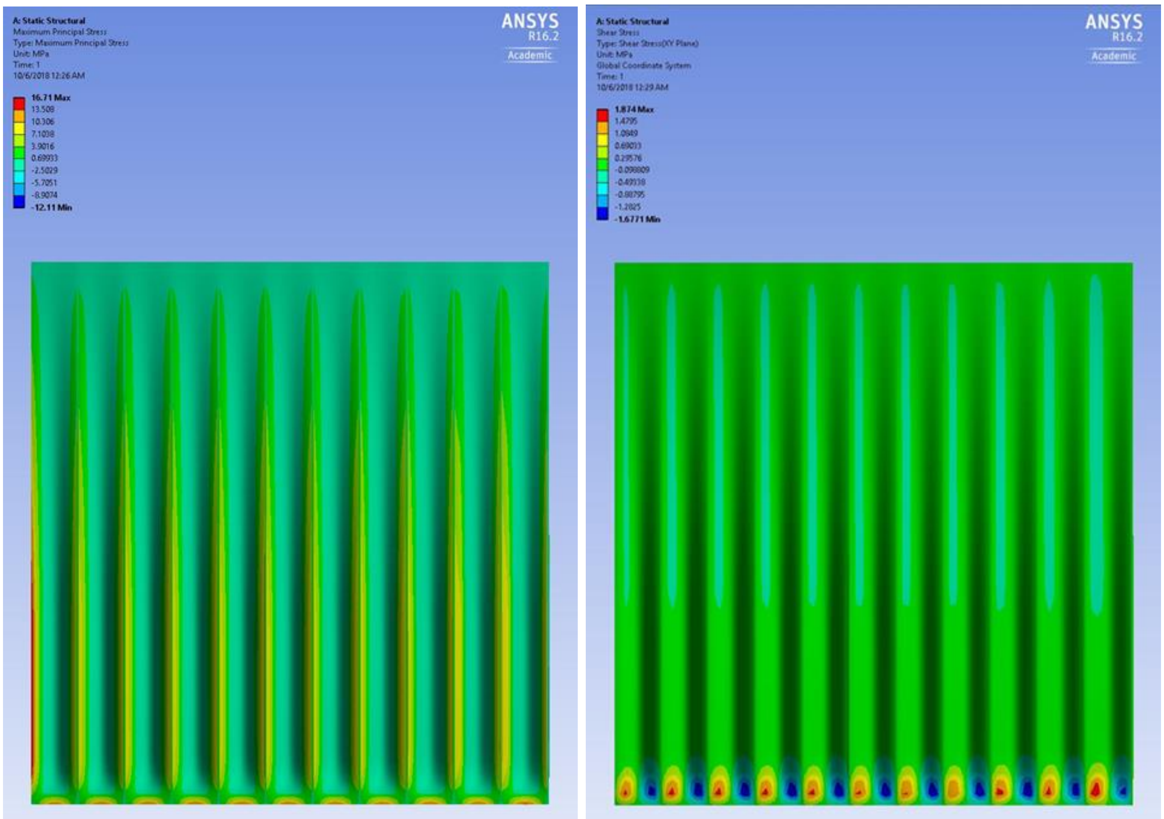

Fig.5 Principal stress (left) and shear stress (right) distribution in the formwork with CPRS

In addition, figure 6 shows a comparison between the deformation pattern of simple formworks and CPRS formworks. As can be seen, the usage of CPRS has reduced the maximum deformation of formwork from 7.18 mm to 5.35 mm. A summary of numerical results are collected in the table 2. Based on this table, usage of CPRS has reduced the maximum principal stress, the maximum shear stress and the maximum deformation of formwork by 27%, 30.2% and 25.5% respectively.

Table 2 A summary of the numerical results

	CSR System	**CPRS**		**Reduction**
	Formwork	**Formwork**	**Sacrificial Sheets**	**(%)**
Maximum Principal Stress (MPa)	22.88	16.71	149.9	27
Maximum Shear Stress (MPa)	2.68	1.87	36.69	30.2
Maximum Deformation (mm)	7.18	5.35	3.07	25.5

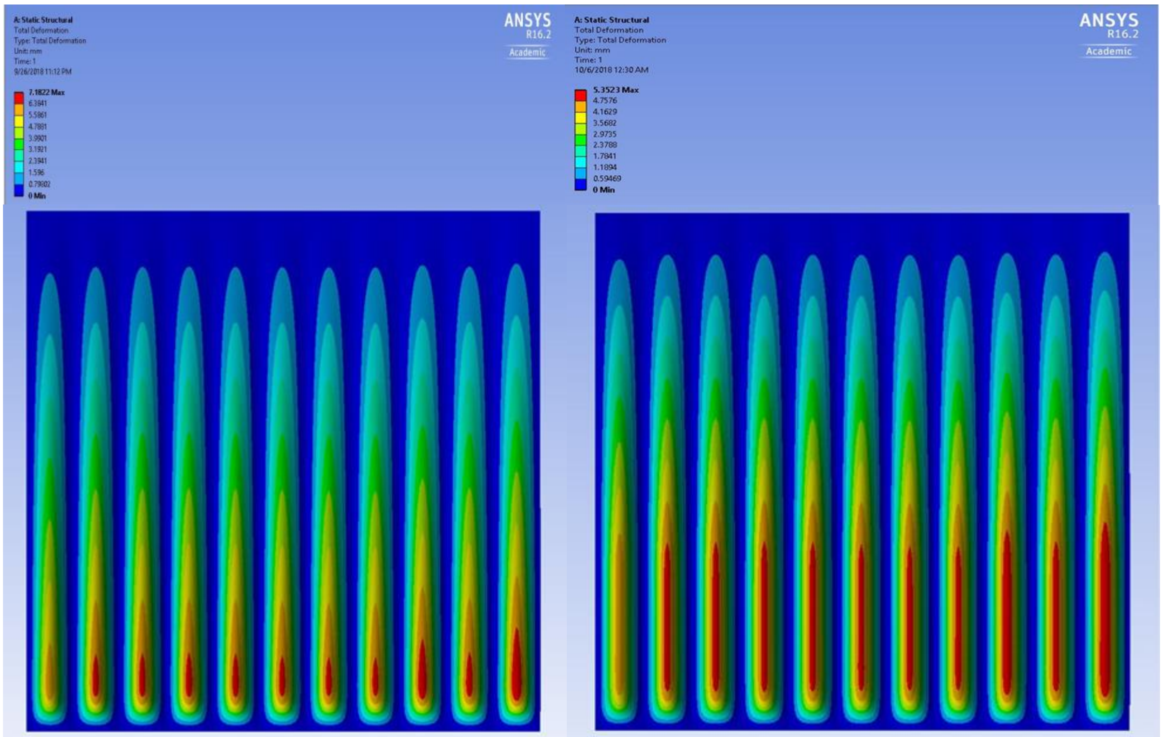

Fig.6 Comparison between deformation pattern of simple (left) and CPRS (right) formworks

5. Conclusion

- This research introduces an innovative system called the Concrete Pressure Reduction System (CPRS), which incorporates sacrificial perforated sheets.
- The CPRS effectively manages the lateral pressure exerted by the concrete and mitigates excessive pressure on the formwork.
- Numerical modeling demonstrated that the utilization of this system can reduce the maximum principal stress by a minimum of approximately 27%
- Numerical modeling demonstrated CPRS reduces the maximum shear stress, and maximum deformation, 30%, and 25%, respectively.
- Deformation obtained from parametric studies were verified through experimental tests, which displayed reasonable agreement with the outcomes of the study.

6. References

[1] ASTM C989 (2014). “Specification for ground granulated blast-furnace slag for use in concrete and mortars”. American Society for Testing and Materials.

[2] Puente I., Santilli A., Lopez A. (2010). ”Lateral pressure over formwork on large dimension concrete blocks”. Engineering Structures, 32 (1), pp. 195-206.

[3] Assaad J., Khayat K.H. (2005). “Effect of coarse aggregate characteristics on lateral pressure exerted by self-consolidating concrete.” ACI Mater. J., 102(3), 145–153.

[4] Assaad J., Khayat K.H. (2006). “Effect of viscosity-enhancing admixtures on formwork pressure and thixotropy of self-consolidating concrete.” ACI Mater. J., 103(4), 280–287.

[5] Beitzel M.; Muller; Harald S. (2004). “Modeling fresh concrete pressure on vertical

formwork," CD ROM, Proceedings of the 5th international symposium in civil engineering, Taylor & Francis Group, London, pp 1-6.
[6] Khayat K., Assaad J., Mesbah H., Lessard M. (2005). "Effect of section width and casting rate on variations of formwork pressure of self-consolidating concrete materials and structures/materiaux et constructions", 38 (275), pp. 73-78.
[7] Proske T. (2007). "Formwork pressure using self-compacting concrete", Ph.D. Thesis, Technische Universitat Darmstadt, p 310.
[8] Rodin S. (1952). "Pressure of concrete on formwork". Proceedings, Inst Civil Eng., London,1:709_46.
[9] Tejeda-Dominguez F., Lange D.A. (2005). "Effect of formwork material on laboratory measurements of scc formwork pressure," Proceedings of the 2nd north American conference on the design and use of self-consolidating concrete (SCC 2005) and the 4th International RILEM Symposium on self-compacting concrete, evanston, IL, Ed. Shah, S. P., pp. 525-532.
[10] Vanhove Y., Djelal C. and Magnin A., (2004). "Prediction of the lateral pressure exerted by self-compacting concrete on formwork," magazine of concrete research, V.56, No.1, pp.55-62.
[11] Vanhove Y., Djelal C., Magnin, A., (2001). "A prediction of the pressure on formwork by tribometry," pressure vessel and piping conference, emerging technologies for fluids, structures and fluid-structure interactions – 2001, The American Society of Mechanical Engineers, Atlanta, V. 431, pp. 103-110.
[12] Work health and safety act (2015). "Work health and safety regulation, 2011", www.legislation.qld.gov.au
[13] Proske T., Khayat K.H., Omran A., Leitzbach O. (2014). "Form pressure generated by fresh concrete: A review about practice in formwork design materials and structures", 47 (7), pp. 1099-1113.
[14] Johnston D.W. (2010)."Field measurement of concrete lateral pressure in formwork". Construction Research Congress 2010: Innovation for reshaping construction practice - proceedings of the 2010 construction research congress, pp. 1335-1344.
[15] Proske T., Graubner C.A. (2010). "Formwork pressure of highly workable concrete - experiments focused on setting, vibration and design approach". RILEM Bookseries, 1, pp. 255-267.
[16] Puente I., Santilli A., Lopez A. (2010). "Lateral pressure over formwork on large dimension concrete blocks". Engineering Structures, 32 (1), pp. 195-206.
[17] ACI 347-04 (2004): "Guide to formwork for concrete". American Concrete Institute.
[18] Amziane S., and Baudeau P. (2000), "Effects of aggregate concentration and size in fresh concrete pressure on formwork walls," (in French), Materials and Structure, V. 33, No. 225, pp. 50-58.
[19] Arslan M., Osman S., and Serkan S. (2005). "Effects of formwork surface materials on concrete lateral pressure." Constr. Build. Mater., 19 (4), 319–325.
[20] Assaad J. (2004). "Formwork pressure of self-consolidating concrete, influence of thixotropy," Ph.D. Thesis, Department of Civil Engineering, Université de Sherbrooke, 453 pp.

[21] Assaad J., Khayat K.H. (2006). "Effect of viscosity-enhancing admixtures on formwork pressure and thixotropy of self-consolidating concrete." ACI Mater. J., 103(4), 280–287.

[22] Billberg P. (2003). "Form pressure generated by self-compacting concrete," Proceedings of the 3rd International RILEM symposium on self-compacting concrete, Eds. Wallevik, O., and Nielsson, I., Reykjavik, Iceland, pp. 271-280.

[23] DIN 18218:2010-01 (2010): Pressure of fresh concrete on vertical formwork—English translation of DIN 18218:2010-01, Beuth Verlag.

[24] Djelal C. (2001). "Designing and perfecting a tribometer for the study of friction of a concentrated clay-water mixture against a metallic surface," Materials and Structures, V. 34, No. 1, pp. 51-58.

[25] Djelal C., Vanhove Y., Magnin A. (2004). "Tribological behaviour of self-compacting concrete," Cement and concrete research, V. 34, No. 5, pp. 821-828.

[26] Fedroff D.; Frosch; Robert J. (2004). "Formwork for self-consolidating concrete," Concrete International, V. 26, No. 10, 2004, pp. 32-37.

[27] Gardner N.J. (1984). "Formwork pressures and cement replacement by fly ash," concrete international, pp. 50-55.

[28] Graubner C.A., Beitzel H., Beitzel M., Bohnemann C., Boska E., Brameshuber W., Dehn F., Ko¨nig A., Lingemann J., Motzko C., Mu¨ller H.S., Pistol K., Proske T., Stettner C., Zilch K. (2008)."Schalungsbelastung durch Hochleistungsbetone mit fließfa ¨higer Konsistenz—Ein Gemeinschaftsprojekt deutscher Forschungseinrichtungen—Abschlussbericht" (Final Report) F09-7-2008, TU Darmstadt, Institut fu¨r Massivbau.

[29] Graubner C.A., Proske T. (2005). "Formwork pressure: A new concept for the calculation," Proceedings of the 2nd North American conference on the design and use of self-consolidating concrete (SCC 2005) and the 4th International RILEM symposium on self-compacting concrete, Eds. Shah, S. P., Chicago, pp. 605-613.

[30] Gregori A., Ferron R.P., Sun Z., Shah S.P. (2008). "Experimental simulation of self-consolidating concrete formwork pressure". ACI Materials Journal, 105 (1), pp. 97-104.

[31] Khayat K. H.; Assaad J. and Mesbah H. (2002). "Variations of formwork pressure of self- consolidating concrete-effect of section width and casting rate," proceedings of the 1st north american conference on the design and use of self-consolidating concrete, Eds. Shah S. P.; Daczko J. A. and Lingscheit J. N., Chicago, pp. 295-302.

[32] Khayat K.H., Bonen D., Shah S. and Taylor P. (2007). "SCC formwork pressure". The national ready-mix concrete research foundation and the strategic development council, American Concrete Institute.

[33] Leemann A., Hoffmann C. (2003). "Pressure of self-compacting concrete on the formwork," Betonwerk und fertigteil-technik/concrete plant and precast technology, V.69, No.11, pp.48-55.

[34] McCarthy M.J., Dhir R. K., Caliskan S. (2012), Kashif Ashraf M. "Influence of self-compacting concrete on the lateral pressure on formwork". Proceedings of the Institution of Civil Engineers: Structures and Buildings, 165 (3), pp. 127-138.

[35] NF P93-350 (1995). French Standard, "Banches industrialisées pour ouvrages en béton, (Industrial Formwork for Concrete Structures).

[36] Omran A.F., Khayat, K. H. (2013). “Portable pressure device to evaluate lateral formwork pressure exerted by fresh concrete”. Journal of Materials in Civil Engineering, 25 (6), pp. 731-740. Cited 2 times.

[37] Ore E.L., Straughan J.J., (1968). “Effect of cement hydration on concrete form pressure,” ACI Journal, Title No. 65-9, 1968, pp. 111-120.

[38] Ritchie A.G.B. (1962). “The Pressures developed by concrete on formwork,” Civil Engineering and Public Works Review, part 1, v. 57, no. 672; part 2, v. 57, no. 673,10 pp.

[39] Roby H.G. (1935).“Pressure of concrete on forms,” Civil Engineering, V. 5, 162 pp.

[40] Roussel N., Ovarlez G. (2005). “A physical model for the prediction of pressure profiles in a formwork,” Proceedings of the 2nd North American conference on the Design and Use of Self-Consolidating Concrete (SCC 2005) and the 4th International RILEM symposium on self-compacting concrete, eds. Shah, S. P., Chicago, pp. 647-654.

[41] Ruiz-Ripoll L., Shah S., Barragán B. and Turmo J. (2014). "Effect of mix design on fresh self-consolidating concrete and inferences on formwork pressure." Journal of Material for Civil Engineering.

[42] Tejeda-Dominguez F., Lange D.A. (2005). “Effect of formwork material on laboratory measurements of SCC formwork pressure,” Proceedings of the 2nd north american conference on the design and use of self-consolidating concrete (SCC 2005) and the 4th international rilem symposium on self-compacting concrete, Evanston, IL, Ed. Shah, S. P., pp. 525-532.

[43] Vanhove Y., Djelal C., Magnin A., (2000). “Friction behaviour of a fluid concrete against a metallic surface”, international conference on advances in mechanical behaviour, plasticity and damage, elsevier science LTD, Euromat 2000, Tours, V. 1, pp. 679-684.

[44] Wolfgang B. and Stephan U. (2003). “Investigation on the formwork pressure using self- compacting concrete”, Proceedings of the 3rd International RILEM Symposium on self- compacting concrete, Eds. Wallevik, O., and Nielsson, I., Reykjavik, Iceland, pp. 281-287.

[45] Yu D.N. (2000). “Modeling and predicting concrete lateral pressure on formwork”. ph.d. thesis. institute of construction, dept. of civil engineering. North Carolina State University.204 pp.

[46] Khayat K.H., Omran A.F. (2011). “Field verification of formwork.pressure prediction models”. Concr Int 33(6):33–39.

[47] Assaad J.J., Khayat K.H. (2006). “Effect of casting rate and concrete temperature on formwork pressure of self-consolidating concrete (2006) Materials and Structures/Materiaux et Constructions, 39 (287), pp. 333-341.

[48] Perrot, A., Amziane, S., Ovarlez, G., & Roussel, N. (2009). SCC formwork pressure: influence of steel rebars. Cement and Concrete Research, 39(6), 524-528.

[49] Tahmoorian, Farzaneh, Saeed Nemati, Pezhman Sharafi, Bijan Samali, and S. Khakpour. "Punching behaviour of foam filled modular sandwich panels with high-density polyethylene skins." Journal of Building Engineering 33 (2021): 101634.

[50] Nemati, Saeed, Maria Rashidi, and Bijan Samali. "Decision making on the optimised choice of pneumatic formwork textile for foam-filled structural composite panels." GEOMATE Journal 13, no. 39 (2017): 220-228.

[51] Jorge S.P., For Chapter in a Book, Dynamic of Structures, 3rd ed. Vol. 4, Publisher's Name, Year, pp. 15–66.