References

ACI committee 122, 2002. Guide to thermal properties of concrete and masonry systems. (ACI 122R-02), *ACI Manual of Concrete Practice Part 1.*, Detroit, Michigan, USA.

ACI committee 207, 1996. Mass concrete (ACI 207.1-96), *ACI Manual of Concrete Practice Part 1.*, Detroit, Michigan, USA.

ACI committee 207, 1995. Effect of restraint, volume change, reinforcement on cracking of mass concrete (ACI207.2R-95), *ACI Manual of Concrete Practice, Part 1*, Detroit, Michigan, USA.

American Committee 207, 1998. Cooling and insulating systems for mass concrete (ACI 207.4R-93), *ACI Manual of Concrete Practice, Part 1,* Detroit, Michigan, USA.

American Committee 209, 1992. Prediction of creep, shrinkage and temperature effects in concrete structure (ACI 209R-92), *ACI Manual of Concrete Practice, Part 1,* Detroit, Michigan, USA

ACI Committee 517, 1988. Accelerated curing of concrete at atmospheric pressure (ACI 517.2R-80), *ACI Manual of Concrete Practice, Part 6*, Detroit, Michigan, USA

American Society of Heating, Refrigerating and Air-Conditioning Engineer Institute (ASHRAE), 1993. *ASHRAE Handbook fundamental*, Georgia.

Arshad A. K., William D. C. and Denis M., 1998. Thermal properties and transient thermal analysis of structure members during hydration, *ACI Materials Journal* 95, 3: 293-301.

ASTM C531, 2000. Standard test method for linear shrinkage and coefficient of thermal expansion of chemical-resistant mortar, grouts, monolithic surfacing and polymer concrete, *ASTM Standards* 4.05, ASTM International, West Conshohocken, PA.

Atis, C D., 2002. Heat evolution of high-volume fly ash concrete. *Cement and Concrete Research* 32: 751-756.

Autar, K.K., 1997. *Mechanics of Composite Materials*, Boca Raton, New York: CRC Press

Bach, Th., 1986. Flexural and tensile strength, hardened mortar and concrete with fly ash, *Report of RILEM Technical Committee 67-FAB Use of Fly Ash in Building.* Springer Netherlands.

Bai, J., and Wild, S., 2002. Investigation of the temperature change and heat evolution of mortar incorporating PFA and metakaolin. *Cement and Concrete Composites* 24: 201-209.

Ballim, Y. 2004, A numerical model and associated calorimeter for predicting temperature profiles in mass concrete, *Cement and Concrete Composites*, 26, 6: 695-703

Bayazitoglu, Y., and Ozisik, M. N., 1988. *Element of Heat Transfer*, McGraw-Hill International Edition.

Bentz D.P., 2007. Transient plane source measurements of the thermal properties of hydrating cement pastes, *Materials and Structures/Materiaux et Constructions*, 40, 10: 1073-1080.

Bentz, D. P., Waller, V., and Larrard, F. D., 1998. Prediction of adiabatic temperature rise in conventional and high-performance concrete using a 3-D microstructure Model., *Cement and Concrete Research* 28: 285-297.

Berwanger, C., and Sarkar, A.F., 1976. Thermal expansion of concrete and reinforced concrete, *Journal of American Concrete Institute* 73, 11: 618-621.

Bjontegaard, O., and Sellevold, E.J., 2001. Interaction between thermal dilation and autogeneous deformation in high performance concrete, *Materials and Structures* 34, 1: 266-272

Brown, T.D. and Javaid, M.Y., 1970. The thermal conductivity of fresh concrete. *Materials and Structures/Materiaux et Constructions*, 3, 18: 411-416.

Buffo-Lacarriere, L., Sellier, A., Escadeillas, G. and Turatsinze, A., 2007. Multiphasic finite element modeling of concrete hydration, *Cement and Concrete Research* 37, 2: 131-138

Isgor, B.O. and Razaqpur G.A., 2004. Finite element modeling of coupled heat transfer, moisture transport and carbonation processes in concrete structures, *Cement and Concrete Composites* 26, 1: 57-73.

Campbell-Allen, D. and Thone, CP., 1963. The thermal conductivity of concrete, *Magazine of Concrete Research* 15, 43: 39-48.

Cervera, M., Faria, R., Oliver, J. and Prato, T., 2002. Numerical modeling of concrete curing, regarding hydration and temperature phenomena, *Computers & structures* 80, 18-19: 1511-1521

Childs, P., Wong, A.C.L., Gowripalan, N., and Peng, G.D., 2007. Measurement of the coefficient of thermal expansion of ultra-high strength cementitious composites using fibre optic sensors, *Cement and Concrete Research* 37, 5: 789-795

Coefficient of thermal expansion, http://www.supercivilcd.com/THERMAL.htm, 2006.

Demirboğa, R., 2003. Thermo-mechanical properties of sand and high volume mineral admixtures, *Energy and Buildings* 35, 5: 435-439.

Demirboğa, R., 2003, Influence of mineral admixtures on thermal conductivity and compressive strength of mortar, *Energy and Buildings*, 35, 2: 189-192.

Demirboğa R., 2007, Thermal conductivity and compressive strength of concrete incorporation with mineral admixtures, *Building and Environment*, 42, 7: 2467-2471.

Demirboğa, R., Türkmen, I. and Karakoç, M.B., 2007. Thermo-mechanical properties of concrete containing high-volume mineral admixtures, *Building and Environment*, 42, 1: 349-354.

Department of the Army U.S. Army corps of Engineers, 1997. Engineering and Design Thermal Studies of Mass Concrete Structures, *Engineer Technical Letter ETL1110-2-542*, Washington D. C.

Evsukoff, A.G., Fairbairn, E.M.R., Faria, E.F., Silvoso, M.M. and Filho, R.D.T., Modeling adiabatic temperature rise during concrete hydration: a data mining approach, *Computers & Structures* 84, 31-32: 2351-2362

Faria, R., Azenha, M, and Figueiras, J.A., 2006. Modelling of concrete at early ages: application to an externally restrained slab, *Cement and Concrete Composites* 28, 6: 572-585

Gambhir, M.L., 2004. *Concrete Technology*, Tata McGraw-Hill Publishing Company Limited.

Hansen, P.F., Hansen, J.H., Kjaer, U. and Pedersen, E.J., 1982. Thermal properties of hardening cement paste, *International Conference on Concrete of Early Ages,* Paris: 23-26.

Houghton, D.L., 1976. Determining tensile strain capacity of mass concrete, *Journal of American Concrete Institute* 73, 12: 691-700

Ivan, E.H., James, JR., Paxton A. and Houghton D.L., 1970. Prediction of thermal stress and strain capacity of concrete by tests on small beams, *Journal of American Concrete Institute* 67, 3: 253-261.

Janna, W.S., 1986, *Engineering heat transfer*, United States of America: PWS Publishers,
Jindawanik, T., Chukiert, K. and Wasuwat, P., 2000. Weather data of Thailand for energy conservation 1981 – 1998 [CD-ROM], Chulalongkorn University, Thailand.

Jitvutikrai, P., 2000. *Model for Predicting Heat of Hydration and Thermal Properties of Fly Ash Concrete*. Master Thesis. Sirindhorn International Institute of Technology and Faculty of Engineering, Thammasat University, Pathumthani, Thailand.

Jonasson, J.E., Groth, P. and Hedlund, H., 1994. Modelling of temperature and moisture field in concrete to study early age movement as a basis for stress analysis, in : R. Springenschmid (Ed.), *Thermal Cracking in Concrete at Early Ages*, E & FN Spon, pp. 45 – 52.

Kada, H., Lachemi, M., Petrov, N., Bonneau, O. and Aïtcin, P.C., 2002. Determination of the coefficient of thermal expansion of high performance concrete from initial setting, M*aterials and Structures* 35, 1: 35-41.

Khan M. I., 2002, Factors affecting the thermal properties of concrete and applicability of its prediction models, *Building and Environment*, 37, 6: 607-614.

Khunthongkeaw, J., and Tangtermsirikul, S., 2002. A model for simulating carbonation of fly ash concrete, *In Proceeding of The Eighth National Convention on Civil Engineering*, Khon Kaen, 1: Mat-97 – Mat-102.

Kim, J.-K., Han, S.H. and Song, Y.C., 2002. Effect of temperature and aging on the mechanical properties of concrete part I. experimental results, *Cement and Concrete Research* 32, 7: 1087-1094

Kim K.-H., Jeon S.-E, Kim J.-K., Yang S., 2003. An experimental study on thermal conductivity of concrete, *Cement and Concrete Research*, 33 3: 363-371.

Kishi, T., and Maekawa, K., 1996. Hydration heat model for blended cement including blast slag and fly ash. *Proceedings of the Cairo First International Conference on Concrete Structures*, Cairo, Egypt, 1:4-10 - 4-19.

Kokubu, M., 1969. Fly ash and fly ash cement. In: *Proceedings of the Fifth International Symposium on the Chemistry of Cement*, Part IV. Tokyo: Cement Association of Japan; 75–105.

Klieger P. and Lamond J. F., *Signifinance of Tests and Properties of Concrete and Concrete-Making Materials*, 4th edn, ASTM Publication, Pennsylvania, 1994.

Koenders, E. A. B. and Breugel, K. V., 1994. Numerical and experimental adiabatic hydration curve determination. *The Proceeding of the International RILEM Symposium on Thermal Cracking in Concrete at Early Ages.*, Munich, 1:3-10.

Kwak H.-G., Ha S.-J. and Kim J.-K., 2006. Non-structural cracking in RC walls: Part I. finite element formulation, *Cement and Concrete Research*, 36, 4: 749-760.

Kwak H.-G. and Ha S.-J., 2006. Non-structural cracking in RC walls: Part II. quantitative prediction model, *Cement and Concrete Research* 36, 4, 761-775

Lam, L., Wong, Y. L and Poon, C. S., 2000. Degree of hydration and gel/space ratio of high-volume fly ash/cement systems. *Cement and Concrete Research* 30: 747-756.

Langan, B. W., Weng, K., and Ward, M. A., 2002. Effect of silica fume and fly ash on heat of hydration of portland cement. *Cement and Concrete Research* 32: 1045-1051.

Lu H.R., Swaddiwudhipong S. and Wee T.H., 2001. Evaluation of thermal crack by a probabilistic model using the tensile strain capacity, *Magazine of Concrete Research*, 53, 1: 28 -30.

Maekawa, K., Chaube, R. and Kishi, T., 1999. *Modelling of Concrete Performance*, E & FN Spon, London,

Mangutoval, B, Angjuševal, B., Miloševski, D., Fidanevskal, E., Bossert, J. and Miloševskil, M., 2004. Utilization of fly ash and waste glass in production of glass ceramics composites, *Bulletin of the Chemists and Technologists of Macedonia*, 23, 2: 157–162.

Meinhard, K. and Lackner, R., 2008. Multi-phase hydration model for prediction of hydration-heat release of blended cements, *Cement and Concrete Research* 38, 6: 794-802

Mom, M, 1999. *Modeling Physical and Chemical Effects of Fly Ash on Hydration-heat of Concrete*, Master Thesis. Asian Institute of Technology, Pathumthani, Thailand.

Nanayakkara, S.M.A., 2001. An experimental method to determine the thermal conductivity of concrete. *Proceedings of the International Conference on Advanced Technologies in Design, Construction and Maintenance of Concrete Structures*, Hanoi, Vietnam, 533-539.

Neekhra S., A new mineralogical approach to predict the coefficient of thermal expansion of aggregate and concrete, Master Thesis, Department of Civil Engineering, Texas A&M University, US. 2004.

Park K.-B., Jee N.-Y., Yoon I.-S. and Lee H.-S., 2008. Prediction of temperature distribution in high-strength concrete using hydration model, *ACI Materials Journal*, 105, 2: 180-186.

Poppe A.-M. and Schutter G.D., 2006. Analytical hydration model for filler rich binders in self-compacting concrete, *Journal of Advance Concrete Technology*, 4, 2: 259-266

Portland Cement Association, 2003. Design and Control of Concrete Admixtures, 14th ed-CD Version, CD100.1.

Powers, T. C., 1960. Physical properties of cement paste, *Proceedings of the Fourth International Symposium on the Chemistry of Cement*, Washington D.C, 1:577-613.

Priestley, M. and Thurston, S. 1979. Discussion of the Paper Titled "Thermal Calculations for Bridge Design" by Hunt et al. *ASCE Journal Structure Div*, 102 (ST6):1277–1279

Neville, A. M., 1995, *Properties of Concrete*, 4th edn, Longman. London.

Neville A. M. and Brooks. J.J., *Concrete technology*, Harlow, Essex, England : Addison Wesley Longman, 1987 (reprinted 1997).

Rilem Commiision 42-CEA, 1981, Properties of set concrete at early ages, *Materials and Structure*, 14, 84: 339-450

Roller, K.C., 2000. *Heat and Mass Transfer*, Prentice Hall, Ohio.

Ruiz, J.M., Schindler, A.K., Rasmussen, R.O., Kim, P.J. and Chang, G.K., 2001. Concrete temperature modeling and strength prediction using maturity concepts in the FHWA HIPERPAV software. *Proceedings of the seventh international conference on concrete pavements,* Orlando, Florida. 9–13

Saengsoy W., 2002. *Simulation of Thermal Properties and Adiabatic Temperature Rise of Fly Ash Concrete,*. Master Thesis. Sirindhorn International Institute of Technology and Faculty of Engineering, Thammasat University, Pathumthani, Thailand.

Saengsoy, W. and Tangtermsirikul, S., 2003. Model for predicting temperature of mass concrete", *Proceedings of the 1st National Concrete Conference*, Engineering Institute of Thailand, Kanchanaburi, 211-218

Sarker P. K., Jitvutikrai P., Tangtermsirikul S. and Kishi T., Modeling of Temperature Rise in Concrete Using Fly Ash, Concrete Model Code for Asia IABSE Colloquium, Vol. 80, Phuket, Thailand, 1999, pp. 126 – 132.

Schlangen, E., 2000 *Online Help/Manual module HEAT of FEMMASSE, 1990-2000*, FEMMASSE b.v., The Netherlands.

Schutter, G.D., 2002. Finite element simulation of thermal cracking in massive hardening concrete elements using degree of hydration based material laws. *Computers and Structures*, 80, 27-30: 2035–2042

Schutter, G.D., and Taerwe, L., 1995. Specific heat and thermal diffusivity of hardening concrete. *Magazine of Concrete Research* 47, 172: 203-208.

Schutter, G.D. and Taerwe L., 1995. General hydration model for portland cement and blast furnace slag cement, *Cement and Concrete Research* 25, 3: 593-604

Schubert. P., 1991. Deformation behavior in tension, hardened mortar and concrete with fly ash, in: Wesche K. (Ed.) *Report of RILEM Technical Committee 67*-FAB Use of Fly Ash in Building. Chapman & Hall, UK.

Swaddiwudhipong, S., Lu, H.-R. and Wee, T.-H., 2003. Direct tension test and tensile strain capacity of concrete at early age, *Cement and Concrete Research*, 33, 12: 2077-2084

Tangtermsirikul, S., 2003. *Durability and mix design of concrete*, 1st Edition, Printing House of Thammasat University, Rangsit Campus, Pathum Thani, Thailand.

Tangtermsirikul, S. and Nimityongskul, P., 1997. Simulation of concrete shrinkage taking into account aggregate restraint, *Structural Engineering and Mechanics*, 5, 1: 105-113.

Tangtermsirikul, S. and Saengsoy, W., 2002. Simulation of free water content of paste with fly ash. *Research and Development Journal of the Engineering Institute of Thailand*, 13, 4: 1-10.

Tangtermsirikul, S. and Tatong, S., 2001. Modeling of aggregate stiffness and its effect on shrinkage of concrete, *Science Asia* 27, 3: 185-192.

Tatong, S., 2001. *Autogenous Shrinkage Model for Fly Ash Concrete Considering Effect of Reactions, Pore Structure, and Aggregate Restraint.* Master Thesis. Sirindhorn International Institute of Technology and Faculty of Engineering, Thammasat University, Pathumthani, Thailand.

Tatsanagoson, S., 1999. *Durability of Concrete using Limestone Powder.* Master Thesis. Faculty of Engineering, Thammasat University, Pathumthani, Thailand.

Tokyay, M., 1998. Effects of Three Turkish Fly Ashes on the Heat of Hydration of PC-FA Pastes, *Cement and Concrete Research* 18: 957-960.

Tongaroonsri, S. and Tangtermsirikul, S., 2008, Influence of Mixture Condition and Moisture on Tensile Strain Capacity of Concrete, *Science Asia* 34, 1: 59-68.

Toyokazu, S. and Masuda, Y., 1976, Thermal properties of mortar and concrete in hardening process, *Transactions of the Architectural Institute of Japan*, 241, 1-8 (written in Japanese).

Troxell, G.E., Davis, H.E. and Kelly, J.W., 1968. *Effect of Moisture Content of Specimen. Composition and Properties of Concrete*, University of California, Berkeley.

Wang, C. and Dilger, W.H., 1994. Prediction of temperature distribution in hardening concrete, in : Springenschmid R. (Ed.), *Thermal Cracking in Concrete at Early Ages*, E & FN Spon, London, UK, pp. 21-28

Wee, T.H., Lu, H.R. and Swaddiwudhipong, S., 2000. Tensile strain capacity of concrete under various states of stress, *Magazine of Concrete Research*, 52, 3: 185-193

Wesche, K., 1991, Fly ash in concrete properties and performance, *Report of Technical Committee 67-FAB Use of Fly Ash in Building*, RILEM, E&FN Spon, London.

Whittier, S., Olyniec, J. and Mcglohn, R., 2004. Minimizing Temperature Differentials in Mass Concrete, *Concrete International*, 42-45

Xu, Y. and Chung, D.D.L., 2000. Effect of sand addition on the specific heat and thermal conductivity of cement. *Cement and Concrete Research*, 30 1: 59-61.

Yang, Y. and Sato, R., 2002, A new approach for evaluation of autogenous shrinkage of high strength concrete under heat of hydration, *Proceeding of the Third International Research Seminar in Lund*, 51 – 64.

Yomeyama, K, Tanzil, G. and Toyama, M., 1993. Effective tensile young's modulus of early aged concrete through compressive loading. *The 47th Annual Meeting of Japan Cement Association*, 380-385 (in Japanese).

Appendix A

Constant Values used in the Equation of Degree of Hydration

Table A1 Constant values used in the equation of degree of hydration of C_3A

Concrete Temperature (°C)	Constant Values							
	A	B	C	D	E	F	G	H
10	-4.06938	0.049129	-0.42216	10.09511	-14.0212	-0.9655	0.784753	0.333687
20	-4.17908	0.106269	-0.47138	7.927156	-10.7364	-2.57039	0.921031	0.693593
30	-3.39859	0.296314	-0.55268	2.12718	-4.10719	-4.9863	1.088376	1.559
40	-2.90608	0.768764	-0.74659	-23.8933	21.1663	-12.9031	1.771936	2.873297
50	-3.09266	1.443474	-0.90368	-22.5977	19.57978	-12.7054	1.715397	3.579897
60	-3.24235	2.624947	-1.0878	-21.2037	17.69292	-12.2546	1.61376	5.720925
70	-4.78225	5.61163	-1.09638	10.30922	-8.24443	-5.78737	1.029137	6.892024
80	-14.5566	6.447032	-65.0384	16.91427	-16.7869	-2.70296	0.609302	12.2366
90	-42.6139	14.82293	-88.5494	-256.99	-169.615	124.698	-16.5659	50.38467

Table A2 Constant values used in the equation of degree of hydration of C_3S

Concrete Temperature (°C)	Constant Values										
	A	B	C	D	E	F	G	H	I	J	K
10	-1.08201	-0.99529	0.013851	0.004052	-0.62925	1.478509	-4.65724	0.925282	0.217904	0.439323	-1.59458
20	-1.67118	-0.98176	0.059747	0.021567	-18.3534	26.42119	-15.5067	2.258995	0.004603	0.014537	-12.7938
30	-1.50195	-0.89826	0.272802	0.230015	-21.1758	30.13397	-17.6671	2.577856	0.003572	0.010494	-12.9149
40	-0.75758	-0.99746	0.008453	0.021771	1.921579	0.177493	-6.75025	1.405452	0.009303	0.033227	-11.4273
50	-0.0434	-0.99758	0.010217	0.726643	-14.9063	20.46172	-15.2183	2.447338	0.001673	0.005476	-15.1914
60	-0.03392	-0.99841	0.007729	1.147922	-5.17331	7.352293	-10.8381	2.00873	0.001012	0.003364	-16.7265
70	-2.02512	-0.9	0.347004	1.7	-2.267	2.818347	-9.75516	1.943671	0.001	0.002966	-16.0339
80	-5.61024	-0.77031	0.70385	2.464157	4.733088	-5.76766	-7.40278	1.738718	0.000145	0.000474	-21.8503
90	-0.9	-0.95525	0.032706	2.5	29.07608	-42.2786	6.552212	0.162238	0.003254	0.005963	-11.1845

Table A3 Constant values used in the equation of degree of hydration of C_2S

Concrete Temperature (°C)	Constant Values						
	A	B	C	D	E	F	G
10	-0.1044	0.009639	-6.53725	0.018969	-2.41904	-1.58736	0.270018
20	-0.09435	0.00753	-6.59329	0.02646	-2.64995	-1.68012	0.226191
30	-0.08899	0.005672	-6.55968	0.038532	-2.96573	-1.23945	0.313403
40	-0.08536	0.004158	-6.51164	0.055947	-3.30424	-0.92096	0.450459
50	-0.08079	0.002881	-6.51079	0.072116	-3.65246	-0.85088	0.539239
60	-0.07653	0.001616	-6.50881	0.085752	-4.05329	-0.85691	0.61758
70	-0.07075	0.001271	-6.61813	0.110284	-4.29932	-0.91275	0.688759
80	-0.06282	0.000751	-6.82769	0.12021	-4.62214	-1.03427	0.714151
90	-0.05763	0.00019	-6.94227	0.126453	-5.14518	-1.15829	0.769207

Table A4 Constant values used in the equation of degree of hydration of C_4AF

Concrete Temperature (°C)	Constant Values								
	A	B	C	D	E	F	G	H	I
10	-3.88776	0.038789	-0.38128	27.12989	-20.258	11.19422	-1.89931	-0.05843	-1.95249
20	-3.67118	0.067239	-0.48726	14.12189	-8.98434	8.350486	-1.73052	-0.17679	-1.07424
30	-3.66372	0.214787	-0.15767	-0.05303	10.65644	1.297579	-1.03155	-0.04806	-1.88047
40	-3.62601	0.410945	-0.13519	7.970536	6.050119	2.082058	-1.09682	-0.04787	-2.17988
50	-3.51753	0.651008	-0.12522	-11.7002	-3.53173	-2.74543	1.190171	0.064176	-2.26517
60	-3.45555	1.001919	-0.11059	-15.7251	-0.56402	-3.61555	1.312999	0.085418	-2.32391
70	-3.4101	1.48542	-0.10339	-27.7674	9.639312	-6.57992	1.62983	0.10147	-2.47612
80	-3.25494	2.203537	-0.19947	-496.755	428.3339	-127.264	12.83117	0.016213	-4.29969
90	-3.31599	3.185462	-0.17934	-602.922	523.143	-154.836	15.45486	0.018036	-4.36846

Appendix B

Concrete Mix Proportions and Chemical Compositions of Cement Type I used in the Verification of the Adiabatic Test Results

Table B1 Mix proportions of concrete used in adiabatic temperature rise test (Suzuki et al. 1990)

Mix	w/b	r	Cement (kg/m^3)	Fly Ash (kg/m^3)	Water (kg/m^3)	Sand (kg/m^3)	Gravel (kg/m^3)
OPC400	0.392	0	400	0	157	658	1129
OPC300	0.493	0	300	0	148	765	1129
OPC200	0.785	0	200	0	157	862	1089
FA400	0.392	0.2	320	80	157	645	1129
FA300	0.493	0.2	240	60	148	757	1129
FA200	0.785	0.2	160	40	157	854	1089

Table B2 Mineral compositions of cement used in adiabatic temperature rise test (Suzuki et al. 1990)

C_3S (%)	C_2S (%)	C_3A (%)	C_4AF (%)	CS2H (%)
47.2	27	10.4	9.4	3.9

Table B3 Mix proportions of concrete used in adiabatic temperature rise test (Bentz et al. 1998)

Mix	w/b	Cement (kg/m^3)	Water (kg/m^3)	Sand (kg/m^3)	Gravel (kg/m^3)
1	0.30	529.5	158.9	786.7	961.6
2	0.35	455.3	159.3	819.5	1001.6
3	0.65	274.7	178.6	860.8	1052.1

Table B4 Chemical compositions of Portland cement type I (Bentz et al. 1998)

Chemical Component (%)	Cement Type I
Silicon Dioxide (SiO_2)	20.4
Aluminium Oxide (Al_2O_3)	4.7
Ferric Oxide (Fe_2O_3)	2.8
Calcium Oxide (CaO)	62.6
Magnesium Oxide (MgO)	1.9
Sulfur Trioxide (SO_3)	2.7
Loss on Ignition (LOI)	1.9
Sodium Oxide (Na_2O)	0.2
Potassium Oxide (K_2O)	0.9

Appendix C
Properties of Materials and Mix Proportions of Pastes, Mortars and Concretes used in the Verification of Thermal Properties Model

Table C1 Chemical compositions and physical properties of OPC and PFA

Material	SiO_2 (%)	Al_2O_3 (%)	Fe_2O_3 (%)	CaO (%)	MgO (%)	SO_3 (%)	L.O.I. (%)	Blaine Fineness (cm^2/g)	Specific gravity
OPC I	20.20	4.70	3.73	63.40	1.37	1.22	2.72	3190	3.15
OPC V	20.97	3.49	4.34	62.86	3.33	2.12	1.21	3210	3.15
PFA	36.10	19.40	15.10	17.40	2.97	0.77	2.81	2510	2.10

Table C2 Physical properties of crushed limestone sand and natural river sand

Properties	Type of Sand	
Type of Aggregate	Crushed Limestone Sand	Natural River Sand
Specific Gravity (SSD)	2.68	2.61
Absorption (%)	0.82	0.72
Maximum Size, mm.	4.75	4.75
Fineness Modulus	3.98	2.84

Table C3 Mix proportions of concrete and no-fine concrete conducted by Brown and Javaid (1970).

Mix No.	Mix Proportion (kg/m^3)				
	Cement	Fly ash	Water	Fine Aggregate	Coarse Aggregate
Concrete	307	0	200	922	922
No-fine Concrete	322	0	161	0	1934

Table C4 Mix proportions of the tested cement pastes conducted by Toyokazu and Yoshiro (1976)

Mix No.	Mixture Code	w/b	s/b	g/b	Type of Aggregate
1	N30	0.30	0	0	-
2	SN6520	0.65	2	0	Standard Sand
3	SN6530	0.65	3	0	Standard Sand
4	SN5030	0.50	3	0	River Sand
5	RGN	0.65	2	3	River Sand and Gravel

Remark: w: water, c: cement, s: fine aggregate and g: coarse aggregate

Table C5 Thermal conductivities of the aggregates conducted by Toyokazu and Yoshiro (1976)

Type of Aggregate	Specific Gravity	k (kcal/m hr ^{o}C)
River Gravel	2.65	1.85*
Standard Sand	2.59	2.85**
River Sand	2.59	1.80**

*The values were obtained from regression analysis by using the test results of concrete.
**The values were obtained from regression analysis by using the test results of mortar.

Table C6 Thermal conductivities of the aggregates conducted by Khan (2002)

Type of Aggregate	Specific Gravity	k (kcal/m hr ^{o}C)
Sand type I	2.69	3.90*
Sand type II	2.70	2.55*
Basalt	2.70	3.70
Limestone	2.69	3.00
Siltstone	2.66	4.49

*The values were obtained from regression analysis by using the test results of mortar.

Table C7 Mix proportions of mortar and concrete conducted by Khan. (2002)

Mix No.	Type of Coarse Aggregate	Type of Fine Aggregate	Mix Proportion (kg/m^3)				
			Cement	Fly ash	Water	Fine Aggregate	Coarse Aggregate
1	-	Sand Type I	591	0	355	1177	0
2	-	Sand Type II	591	0	255	1181	0
3	Basalt	Sand Type I	316	0	189	628	1261
4	Basalt	Sand Type II	316	0	189	630	1261
5	Limestone	Sand Type I	316	0	189	628	1256
6	Limestone	Sand Type II	316	0	189	630	1256
7	Siltstone	Sand Type I	316	0	189	628	1242
8	Siltstone	Sand Type II	316	0	189	630	1242

Table C8 Mix proportions of concrete conducted by Kim et al. (2003)

Mix No.	Test age (days)	Type of cement	Mix Proportion (kg/m^3)				
			Cement	Fly ash	Water	Fine Aggregate	Coarse Aggregate
C-RE	3,7,14 and 28	Type V	452	0	181	630	989
P-RE	3,7,14 and 28	Type V	1394	0	558	0	0
M-S	3,7,14 and 28	Type V	713	0	285	994	0
M-G	3,7,14 and 28	Type V	894	0	239	0	1304
C-GC1	7	Type V	350	0	140	702	1103
C-GC2	7	Type V	452	0	181	630	989
C-GC3	7	Type V	550	0	220	559	880
C-GC4	7	Type V	650	0	260	490	768
C-GC5	7	Type V	850	0	340	345	546
C-GC6	7	Type V	1050	0	420	206	321
P-WC1	7	Type V	1762	0	440	0	0
P-WC2	7	Type V	1619	0	486	0	0
P-WC3	7	Type V	1498	0	524	0	0
P-WC4	7	Type V	1394	0	558	0	0
P-FL2	7	Type V	696	487	558	0	0
P-1T	7	Type I	1394	0	558	0	0
C-SA1	7	Type V	452	0	181	726	891
C-SA2	7	Type V	452	0	181	810	806
C-SA3	7	Type V	452	0	181	887	729

Table C9 Mix proportion of mortar conducted by Childs et al. (2007)

Mix No.	Mixture Code	w/b	s/b
1	-	0.5	3

Remark: w: water, c: cement and s: fine aggregate

Table C10 Mix proportion of concrete conducted by Kada et al. (2002).

Mix No.	Mix Proportion, kg/m^3				
	Cement	Fly ash	Water	Fine Aggregate	Coarse Aggregate
1	372	0	167	737	990

Table C11 Mix proportion of concrete conducted by Neekhra (2004)

Mix No.	Properties of Coarse Aggregate			Mix Proportion (kg/m^3)				
	Type of Rock	CTE_g (micron/ ^oC)	E_g, x 10^4 (MPa)	Cement	Fly ash	Water	Coarse Aggregate	Fine Aggregate
SRG-1	Siliceous Gravel	12.30	8.95	273	117	163.8	1050	637
SRG-2	Siliceous Gravel	13.10	8.93	273	117	163.8	1050	629
CRG-3	Calcareous Gravel	9.19	12.89	273	117	163.8	1050	633
Lst-5	Limestone	6.35	14.32	273	117	163.8	1050	637
Lst-6	Limestone	6.74	14.36	273	117	163.8	1050	637
Lst-9	Limestone	6.45	14.11	273	117	163.8	1050	633
Sst-12	Sandstone	10.30	10.14	273	117	163.8	1050	660

Remark : Quartz sand is used as fine aggregate.

Appendix D

Mix Proportion of Concrete, Dimension of Specimens and Footing, Physical Properties and Chemical Composition of Ordinary Portland Cement and Fly ash used in the Tests on Semi-Adiabatic Temperature of Specimens in the Lab and Footing.

Table D1 Details of mix proportions CC1, CC2, CC3, CO-OPC, O100, FAA40, FAA50, FAA60, FAB40, FAB50 and FAB60

Mix Designation	(w+sp) /(b)	r	Ingredients (kg/m^3)						Average Ambient Temperature (°C)	Initial Temperature (°C)
			Cement	Fly Ash	Water	Super plasticizer	Fine Aggregate	Coarse Aggregate		
CC1	0.500	0.0	350.00	0.00	175.00	0.00	818.00	1057.00	22	30.0
CC2	0.475	0.0	454.00	0.00	215.00	0.00	723.00	943.00	28	28.0
CC3	0.303	0.0	558.00	0.00	163.00	5.58	810.00	904.00	22	30.0
CO-OPC	0.600	0.0	294.00	0.00	175.00	0.00	937.00	966.00	22	29
O100	0.410	0.0	350.00	0.00	144.00	0.00	728.60	1124.00	23.5	30.2
FAA40	0.475	0.4	205.00	137.00	162.00	0.00	801.00	1035.00	22	30.0
FAA50	0.475	0.5	174.00	174.00	165.00	0.00	781.00	1018.00	28	29.0
FAA60	0.475	0.6	135.00	202.00	160.00	0.00	790.00	1021.00	22	29.0
FAB40	0.500	0.4	210.00	140.00	175.00	0.00	786.00	1017.00	22	29.0
FAB50	0.475	0.5	176.00	176.00	167.00	0.00	792.00	1032.00	26	29.0
FAB60	0.475	0.6	141.00	211.00	167.00	0.00	793.00	1025.00	22	29.0

Table D2 Details of dimension, thickness of foam and plywood of CC1, CC2, CC3, CO-OPC, O100, FAA40, FAA50, FAA60, FAB40, FAB50 and FAB60

Mix Designation	Dimension (mm.)			Thickness of foam (mm.)	Thickness of plywood (mm.)
	Width	Length	Height		
CC1	400	400	400	25	15
CC2	410	410	410	20	15
CC3	400	400	400	25	15
CO-OPC	270	300	450	20	10
O100	400	400	400	25	18
FAA40	400	400	400	25	15
FAA50	410	410	410	20	15
FAA60	400	400	400	25	15
FAB40	400	400	400	25	15
FAB50	410	410	410	20	15
FAB60	400	400	400	25	15

Table D3 Physical properties of Ordinary Portland cement type I, FAA and FAB

Physical properties	Cement type I (CC1 – CC3)	Cement type I (CO-OPC)	Cement type I (O100)	Fly ash type A (FAA)	Fly ash type B (FAB)
Specific gravity	3.13	3.14	3.13	1.9172	2.2168
Specific surface (cm^2/g)	3350	3380	3217	1990	1990
Loss on ignition (%)	1.20	1.13	0.8	0.57	1.54

Table D4 Chemical composition of Ordinary Portland cement, FAA and FAB

Chemical component (%)	Cement type I (CC1 – CC3)	Cement type I (CO-OPC)	Cement type I (O100)	Fly ash type A (FAA)	Fly ash type B (FAB)
Silicon dioxide (SiO_2)	20.30	20.58	20.5	46.02	40.14
Aluminium Oxide (Al_2O_3)	6.41	5.71	6	26.79	19.84
Ferric Oxide (Fe_2O_3)	2.87	2.94	3.2	10.09	11.50
Calcium Oxide (CaO)	64.60	64.76	65.3	8.36	16.84
Sulfur Trioxide (SO_3)	2.29	2.63	2.74	1.20	3.18
Gypsum	4.9	4.9	5.89	-	-

Table D5 Details of mix proportions of footing

Footing Number	Brand of Cement	Dimension (m.)			r	Ingredients (kg/m^3)				
		Width	Length	Depth		Cement	Fly Ash	Water	Fine Aggregate	Coarse Aggregate
F1	Elephant	16.4	21.15	3.0	0.50	196	196	166	730	1130
F2	TPI	13.2	24.9	2.5	0.36	225	125	170	855	1080
F3	TPI	18.6	31	2.5	0.35	265	145	160	790	1120
F4	TPI	14.0	17.0	3.5	0.35	255	135	160	810	1100
F5	TPI	23.0	26.8	3.0	0.35	290	155	160	760	1150
F6	TPI	14.0	26.8	3.0	0.35	290	155	160	760	1150
F7	TPI	13.6	26.8	3.0	0.35	290	155	160	760	1150
F8	Elephant	1.0	1.0	1.0	0.50	196	196	162	730	1130
F9	Elephant	17.0	19.0	3.5	0.50	210	210	150	870	1000
F10	Elephant	25.0	40.0	1.8	0.50	194	194	155	740	1140
F11	Elephant	33.0	49.2	3.0	0.50	212	212	166	700	1120
F12	Elephant	8.4	38.4	4.75	0.475	210	190	160	810	1010
F13	Elephant	14.0	63.0	1.4	0.45	242	198	185	780	1000

Table D6 Physical properties of Ordinary Portland cement Elephant and TPI and fly ash

Physical properties	Cement Elephant Brand	Cement TPI Brand	Fly ash FA1	Fly ash FA2
Specific gravity	3.15	3.15	2.0	2.0
Specific surface (cm^2/g)	3286	3440	2474	2474
Loss on ignition (%)	1.20	1.14	0.19	0.19

Table D7 Chemical composition of Ordinary Portland cement Elephant and TPI and fly ash

Chemical compositions (%)	Cement Elephant Brand	Cement TPI Brand	Fly ash, FA1	Fly ash, FA2
Silicon dioxide (SiO_2)	21.21	20.99	37.11	68.94
Aluminium Oxide (Al_2O_3)	5.42	5.22	20.57	16.44
Ferric Oxide (Fe_2O_3)	3.38	3.41	14.01	3.25
Calcium Oxide (CaO)	66.39	64.79	17.66	1.58
Sulfur Trioxide (SO_3)	2.63	2.54	2.85	0.18
Gypsum	5.48	5.48	-	-

Appendix E

Analytical Results of Temperature and Restrained Strain in Center Core of Blocks V2 to V7 Cast with Concrete Mix No. 3

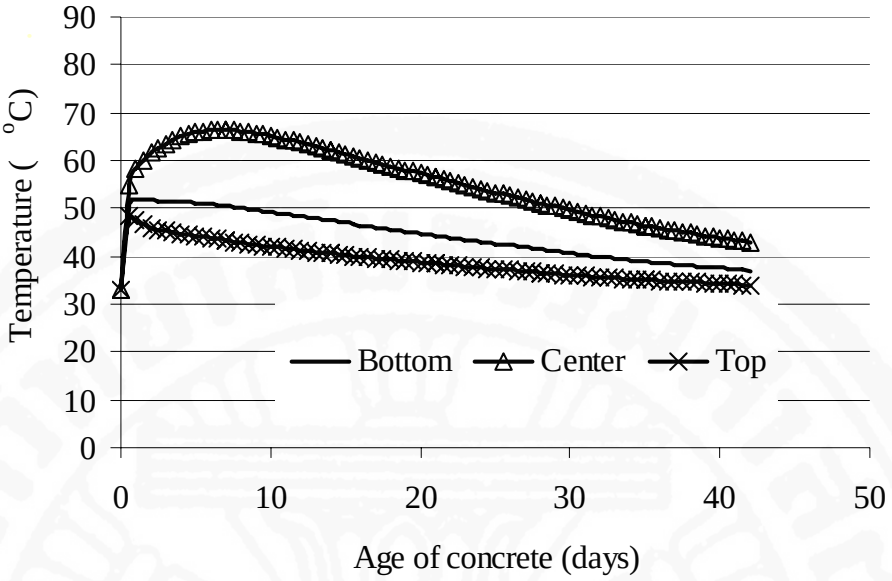

Fig. E1 Predicted temperature in the center core of block V2 cast with concrete mix no. 3

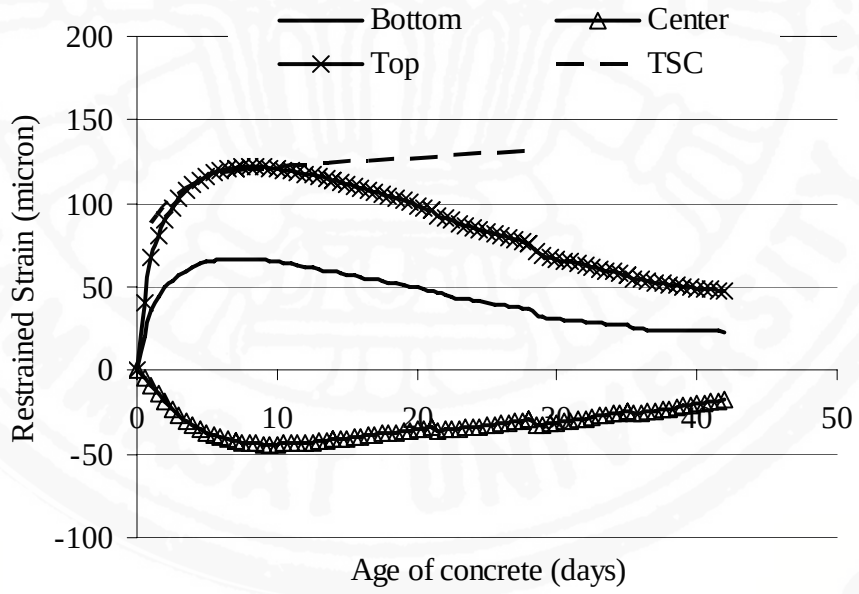

Fig. E2 Predicted restrained strain in longitudinal direction of footing at center core of block V2 cast with concrete mix no. 3

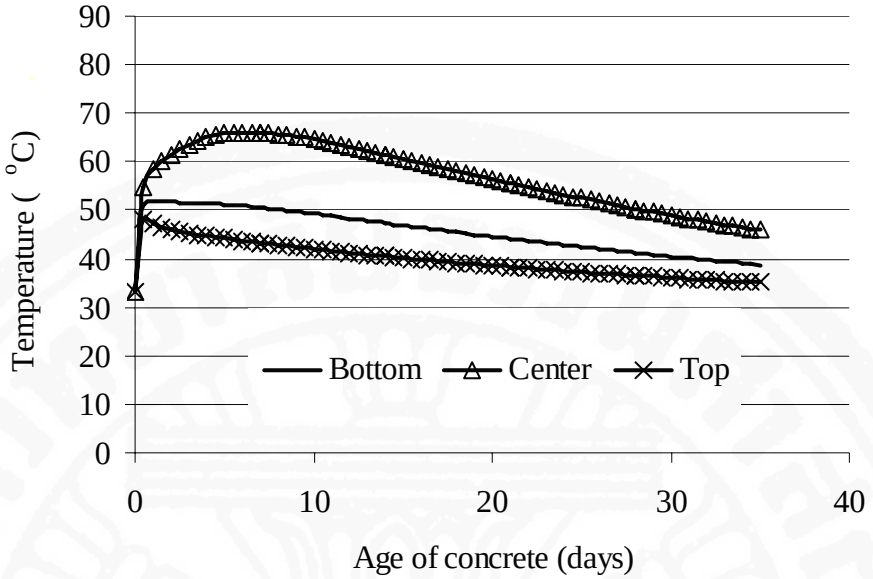

Fig. E3 Predicted temperature in the center core of block V3 cast with concrete mix no. 3

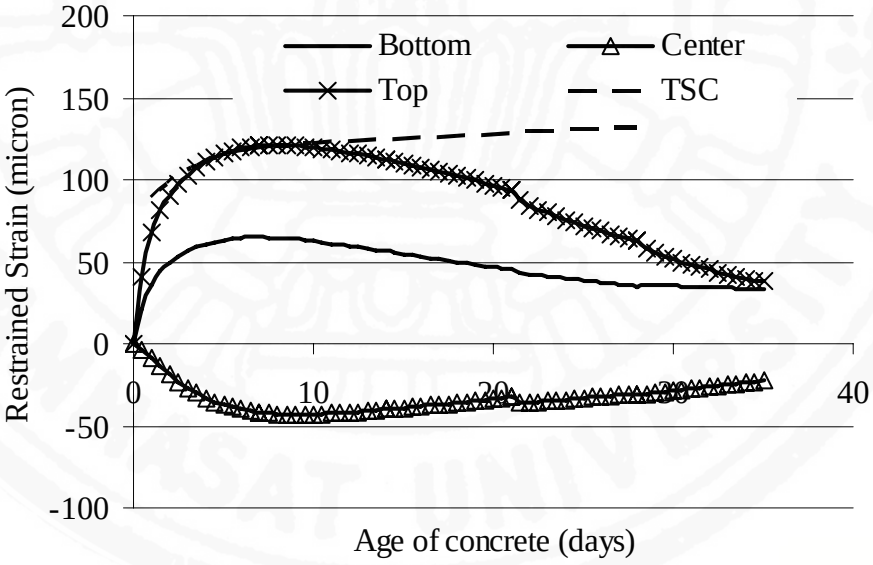

Fig. E4 Predicted restrained strain in longitudinal direction of footing at center core of block V3 cast with concrete mix no. 3

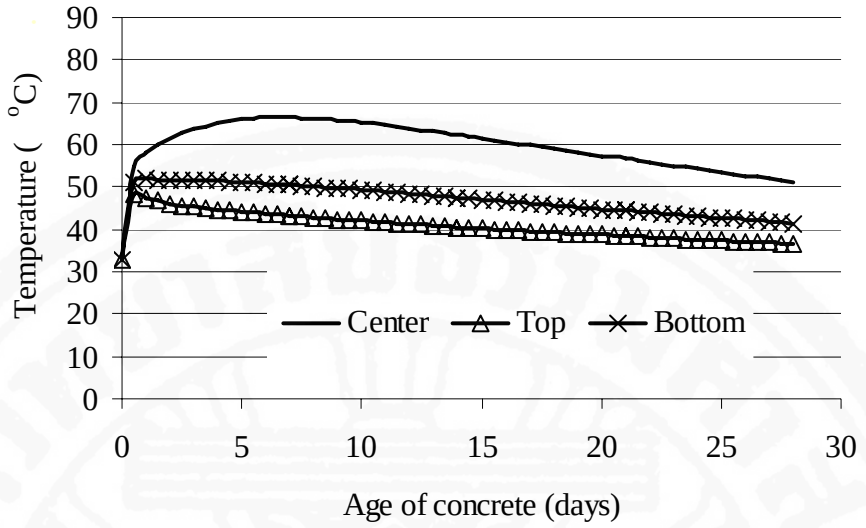

Fig. E5 Predicted temperature in the center core of block V4 cast with concrete mix no. 3

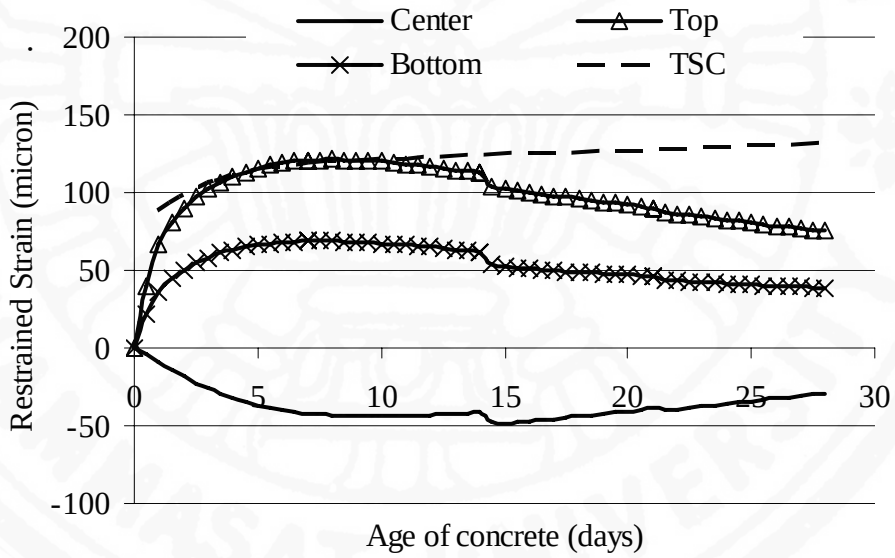

Fig. E6 Predicted restrained strain in longitudinal direction of footing at center core of block V4 cast with concrete mix no. 3

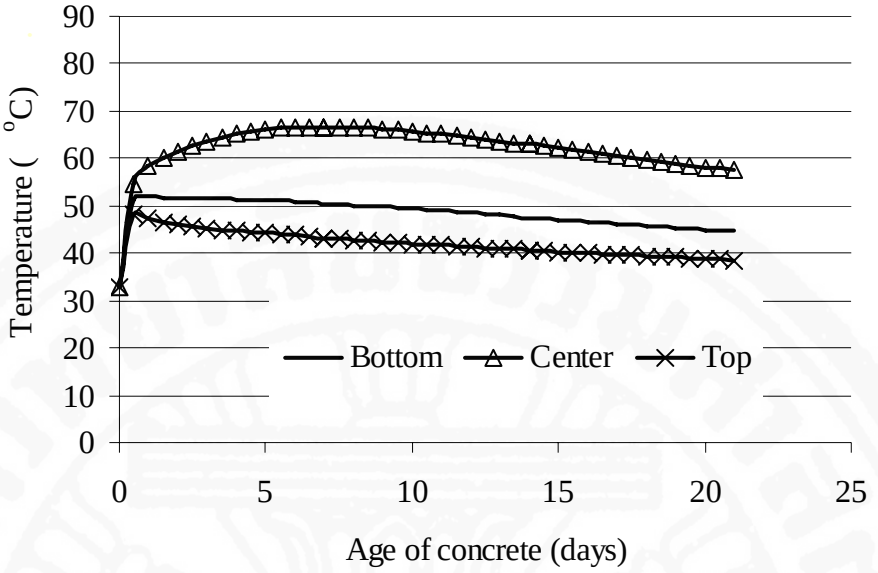

Fig. E7 Predicted temperature in the center core of block V5 cast with concrete mix no. 3

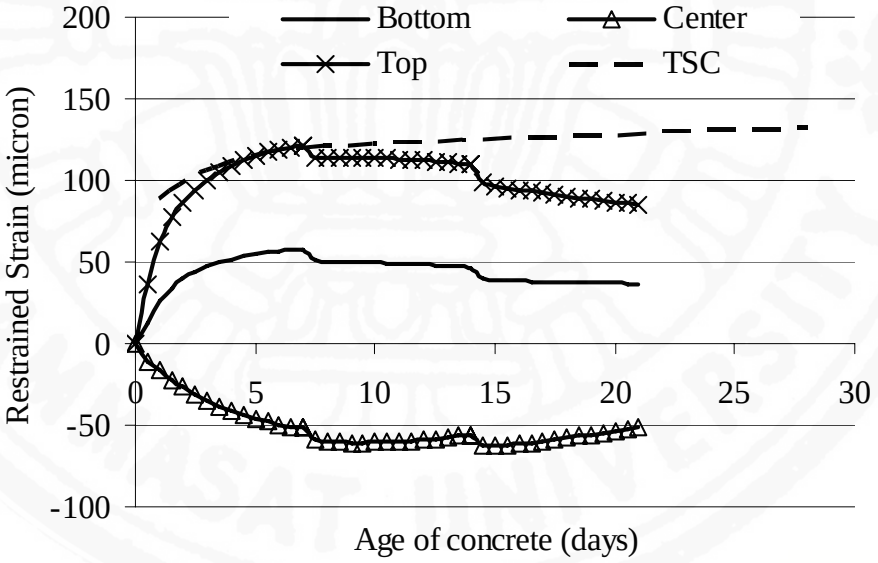

Fig. E8 Predicted restrained strain in longitudinal direction of footing at center core of block V5 cast with concrete mix no. 3

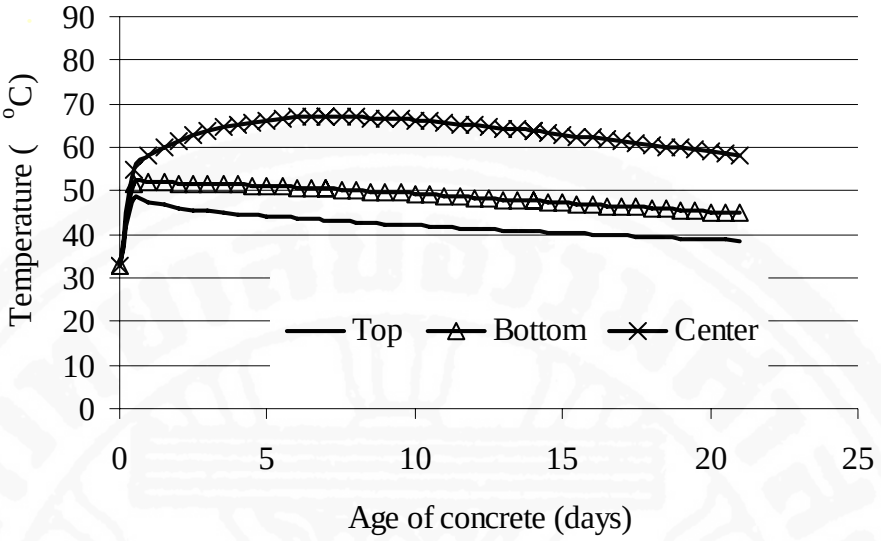

Fig. E9 Predicted temperature in the center core of block V6 cast with concrete mix no. 3

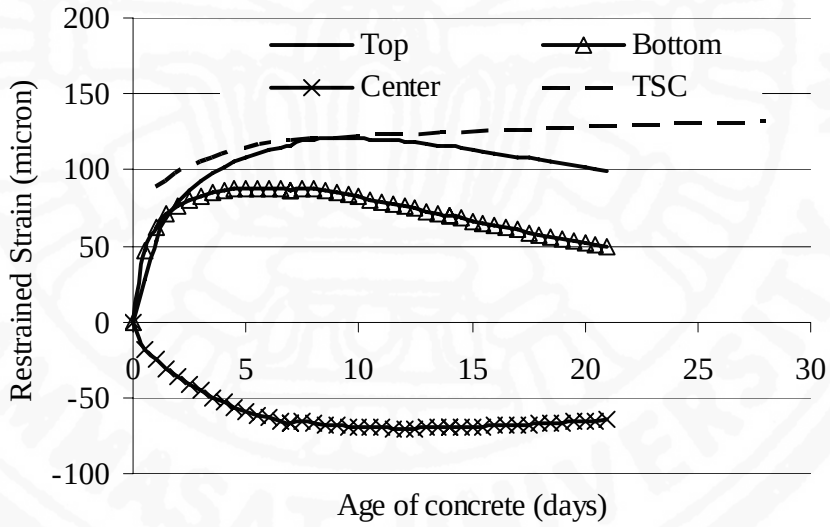

Fig. E10 Predicted restrained strain in lateral direction of footing at center core of block V6 cast with concrete mix no. 3

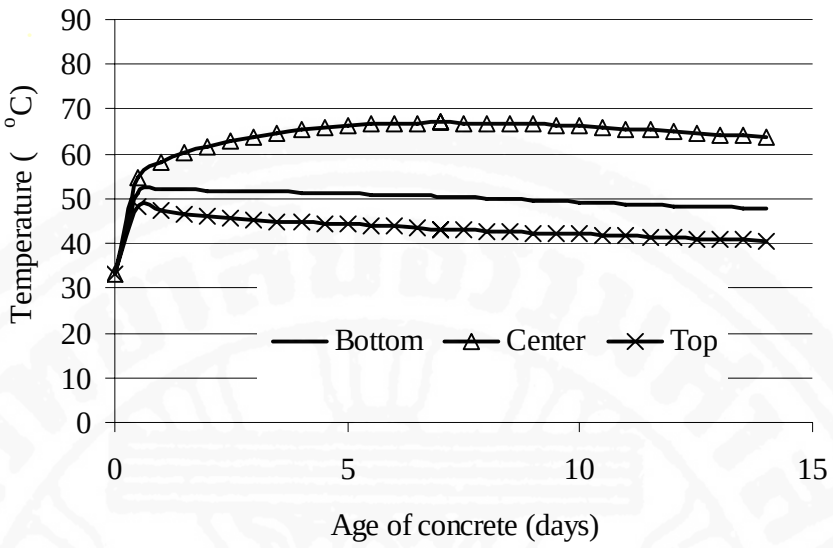

Fig. E11 Predicted temperature in the center core of block V7 cast with concrete mix no. 3

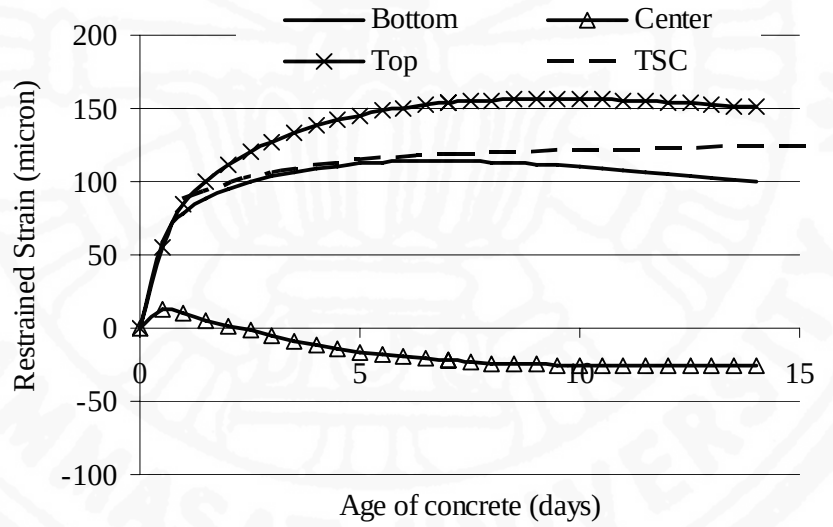

Fig. E12 Predicted restrained strain in lateral direction of footing at center core of block V7 cast with concrete mix no. 3