Durable concrete containing fly ash requires an adequate air void system, good quality control and attention to curing condition at early ages. These are the same procedures which are required to ensure durability in concrete without fly ash.

The production of good quality normal and high strength concrete containing fly ash requires an analysis of the interaction between a particular combination of fly ash and portland cement. This is accomplished by trial batching, performance records and the evaluation of fly ash and portland cement physical and chemical characteristics. The final result is a high quality competitive construction material which can be used in all classes of concrete.

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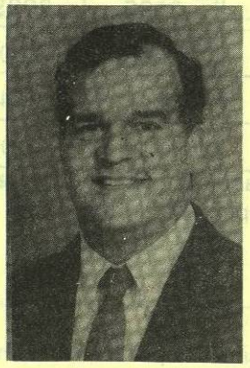

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Table 1. Basic Mixtures Proportions per Cubic Yard

	Cement Content (sacks per cubic yard)			
	5.5	6.0	6.5	7.0
Cement*, lbs.	517	564	611	658
Coarse Aggregate, lbs.	2099	2099	2099	2099
Fine Aggregate, lbs.	1065	970	876	781
Water, lbs.	233	254	275	296
Air, percent	4.0	4.0	4.0	4.0

* Fly ash was used as a weight replacement for the cement and the fine aggregate content was adjusted to correct for proper yield in the mixes containing fly ash.

Table 2. Chemical and Physical Properties of Cement and Fly Ash

	Type I	Type IP	Class C	Class F
Chemical Composition				
Silicon dioxide (SiO_2) (%)	22.0	28.9	31.7	48.5
Aluminum dioxide (Al_2O_3) (%)	4.1	7.9	20.2	23.5
Ferric oxide (Fe_2O_3) (%)	3.1	3.8	5.1	6.4
Calcium oxide (CaO) (%)	65.8	53.1	38.1	10.2
Magnesium oxide (MgO) (%)	0.9	0.1	6.8	1.7
Sulfur trioxide (SO_3)	2.7	- -	4.2	0.9
LOI	0.90	- -	0.26	0.43
Insoluble residue	0.9	- -	- -	- -
Tricalcium silicate (C_3S)	59.0	- -	- -	- -
Tricalcium aluminate (C_3A)	6.0	- -	- -	- -
Total Alkalies	0.6	- -	1.6	0.7
Physical Properties				
Fineness (325 sieve, % retained)	------	------	12.8	12.8
Blaine (cm^2/gm)	3310	3026	----	3189
Vicat: initial, min.	86	106	----	------
final, min.	167	226	----	------
Pozzolanic Activity, %	------	------	97.0	106.1
Moisture, %	------	------	0.15	0.10

Table 3. Compressive strength results of concrete containing fly ash

Mix Designation	C+FA Content ft^3	Fly Ash % by vol. of C+FA	Compressive Strength (psi) 28-day	56-day	91-day	W/(C+FA) by weight	Fly Ash Source
Control #1	4.54	0	9871	11417	12133	.28	
Mix A	4.35	31	10196	11685	12429	.31	W
Mix B	4.26	35	9414	9763	10986	.33	W
Control #2	5.16	0	10154	11661	12332	.26	
Mix C	5.16	35	11474	12704	12568	.24	W
Mix D	5.12	25	9875	12194	13654	.26	W
Mix E	5.07	31	11028	11820	12173	.27	X
Mix F	5.07	30	11620	13151	——	.25	Y
Mix G	5.02	30	12430	——	——	.29	Y

Table 4. Flexural strength results of concrete containing fly ash

Mix Designation	C+FA Content (sks/cu.yd.) ft^3	Fly Ash % by Volume of C+FA	Flexural Strength (psi) 7-day	28-day	w/(C+FA) by weight	Fly Ash Source
Control #1	4.54	0	1242	1323	.28	
Mix A	4.35	31	1098	1321	.31	W
Mix B	4.26	35	1156	1525	.33	W
Control #2	5.16	0	1013	1305	.26	
Mix C	5.16	35	1427	1429	.24	W
Mix D	5.12	25	1137	1388	.26	W
Mix E	5.07	31	910	1192	.27	X
Mix F	5.07	30	1200	1588	.25	Y
Mix G	5.02	30	1663	——	.29	Y

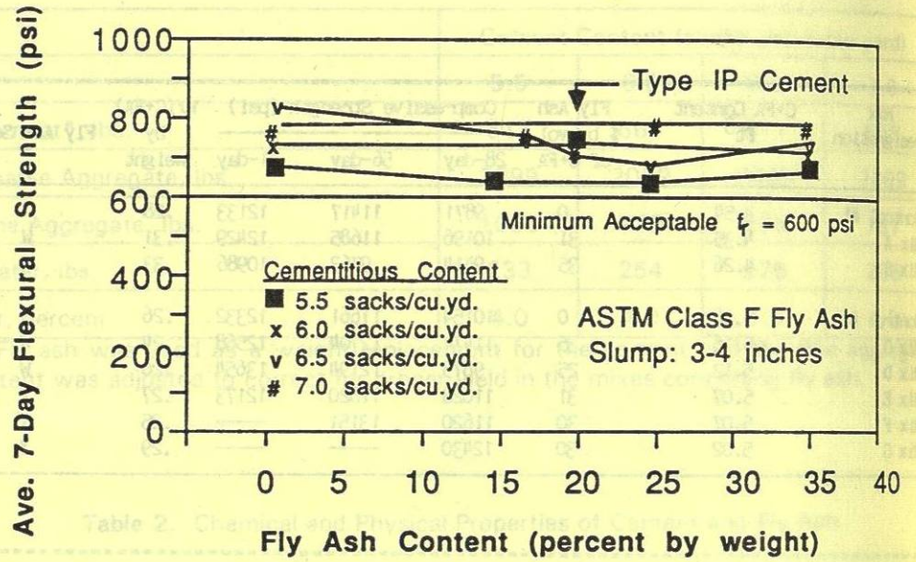


Fig. 1. Flexural strength of concrete containing Class F fly ash

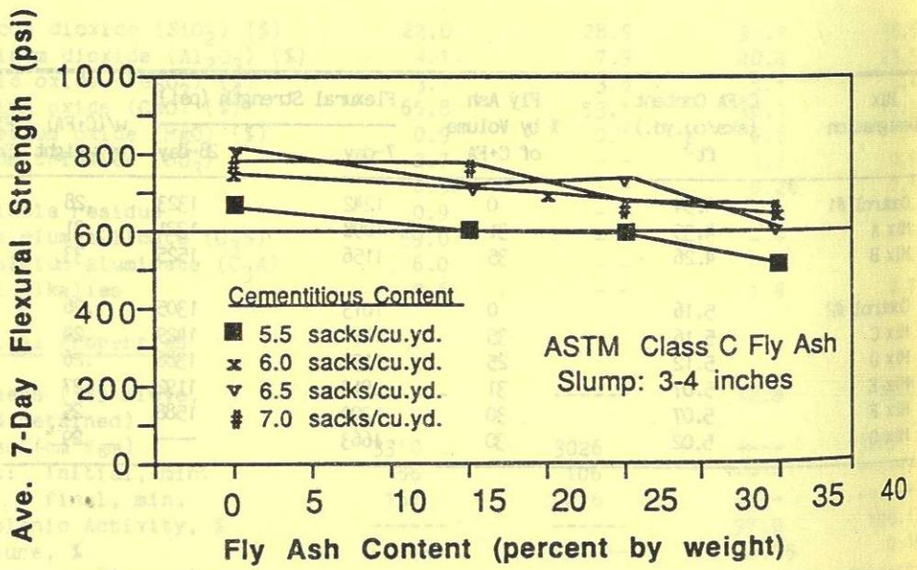


Fig. 2. Flexural strength of concrete containing Class C fly ash.

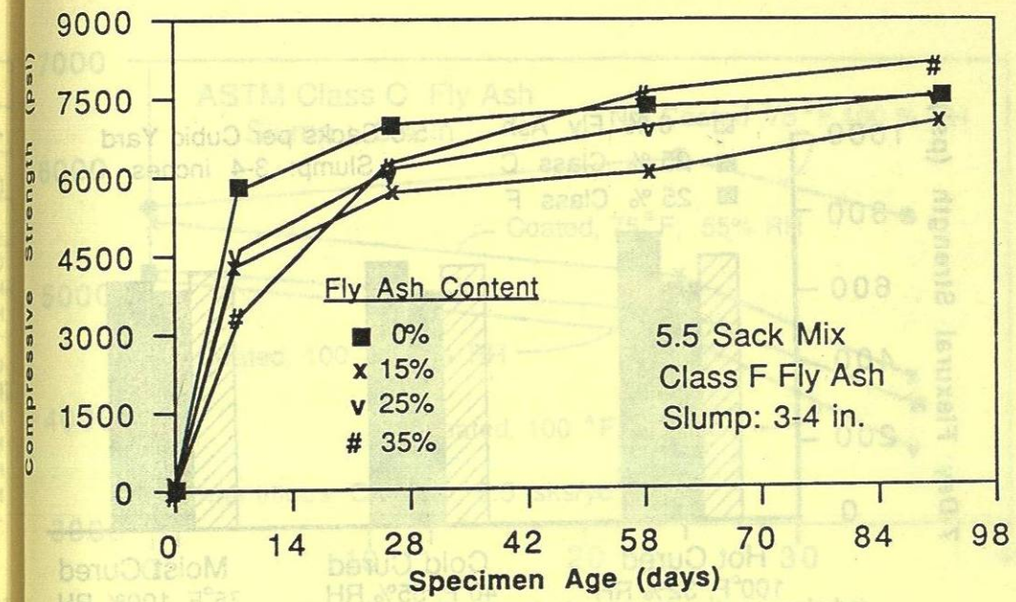


Fig. 3. Compressive strength development of concrete containing Class F fly ash.

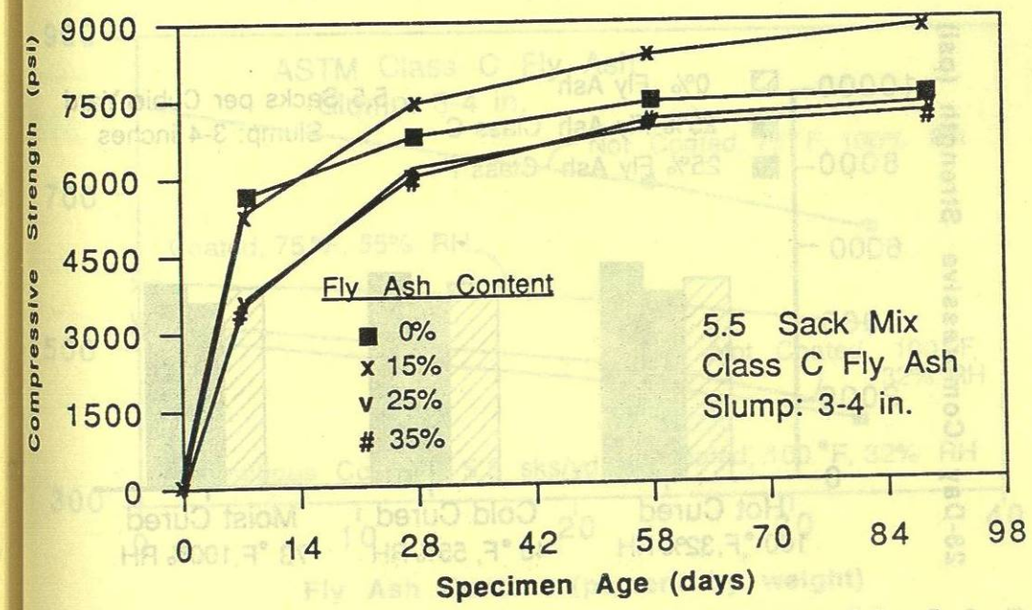


Fig. 4. Compressive strength development of concrete containing Class C fly ash.

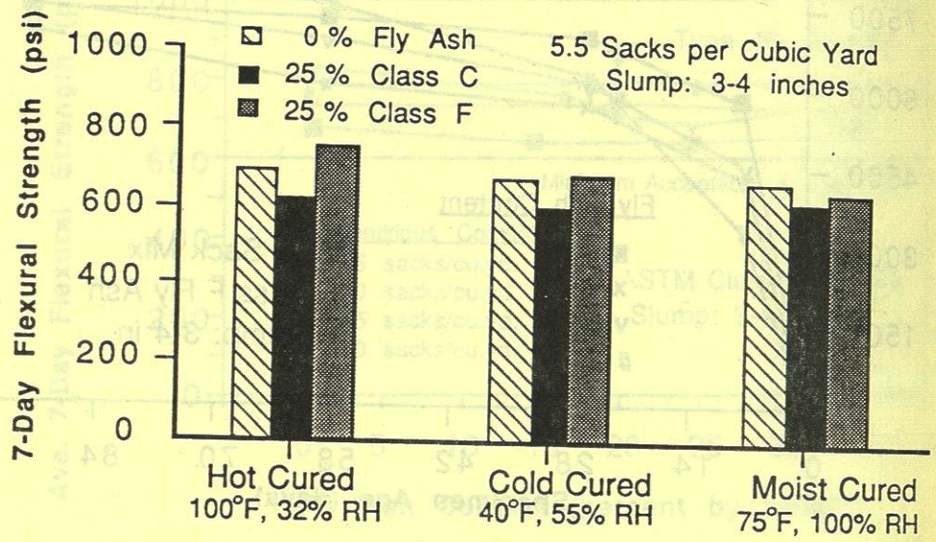


Fig. 5. Flexural strength of concrete containing fly ash under several curing conditions.

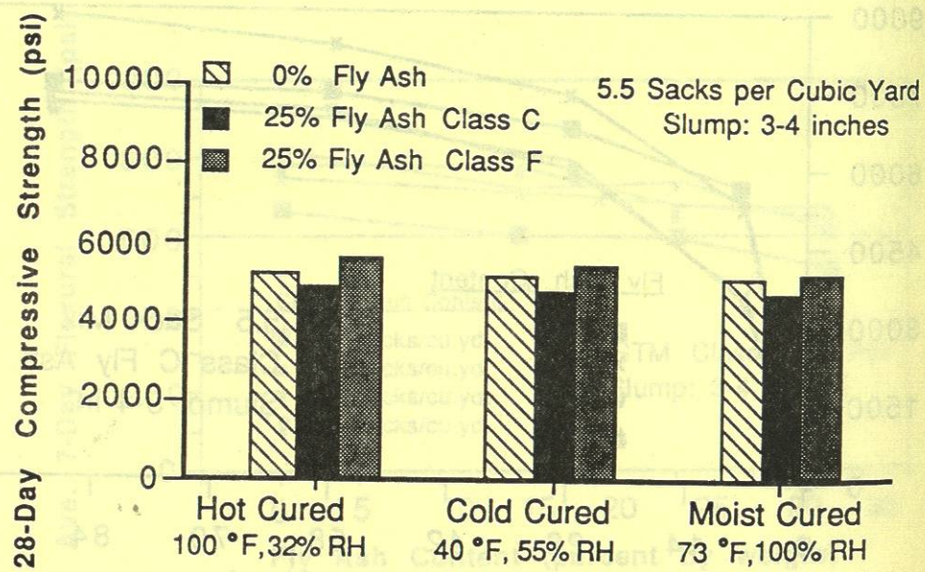
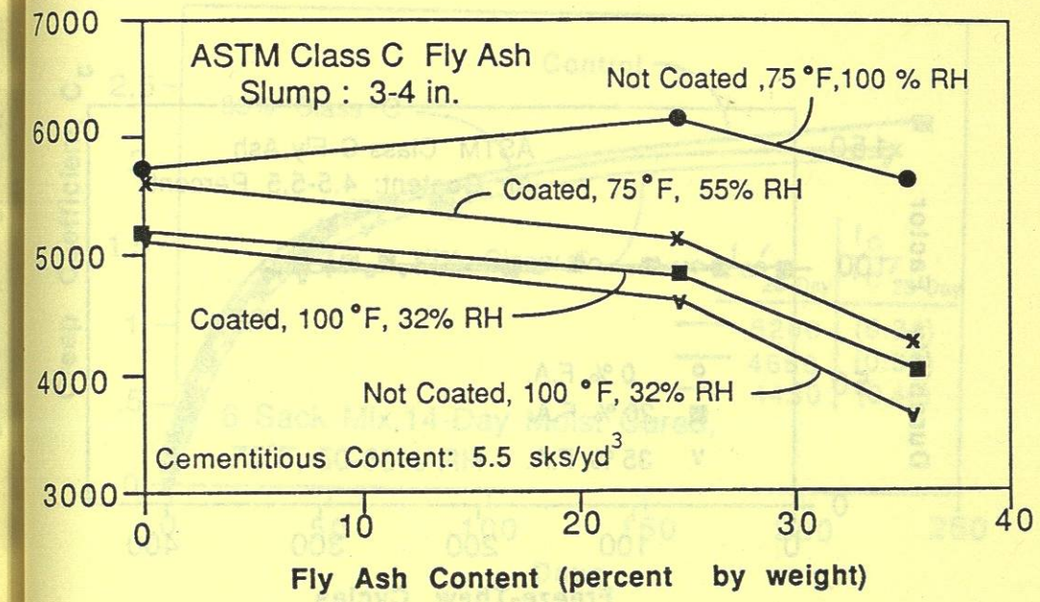
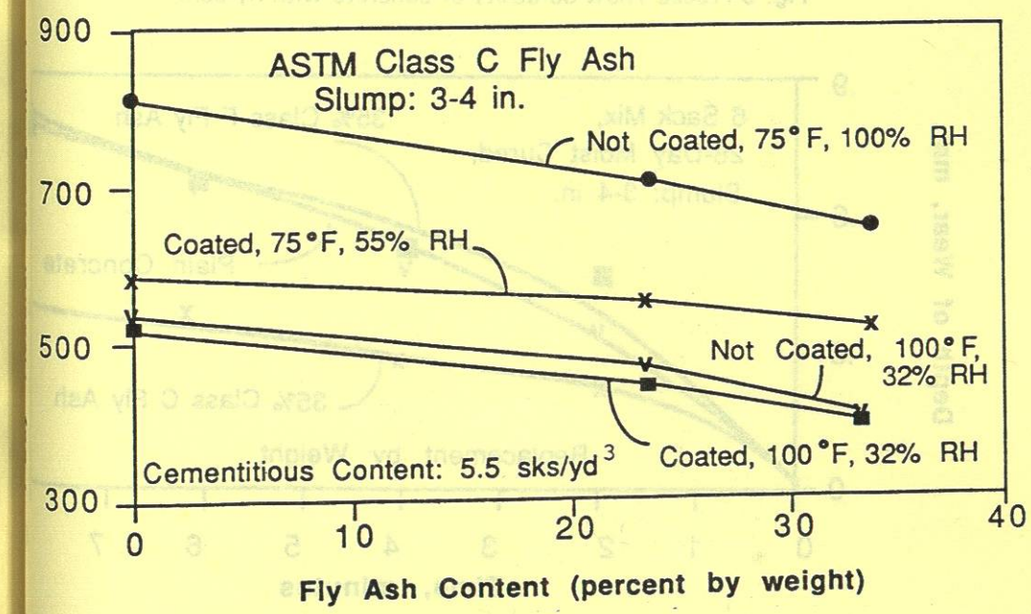


Fig. 6. Compressive strength of concrete containing fly ash under several curing conditions.



g. 7. Compressive strength of concrete with and without membrane curing compound.



g. 8. Flexural strength of concrete with and without membrane curing compound.

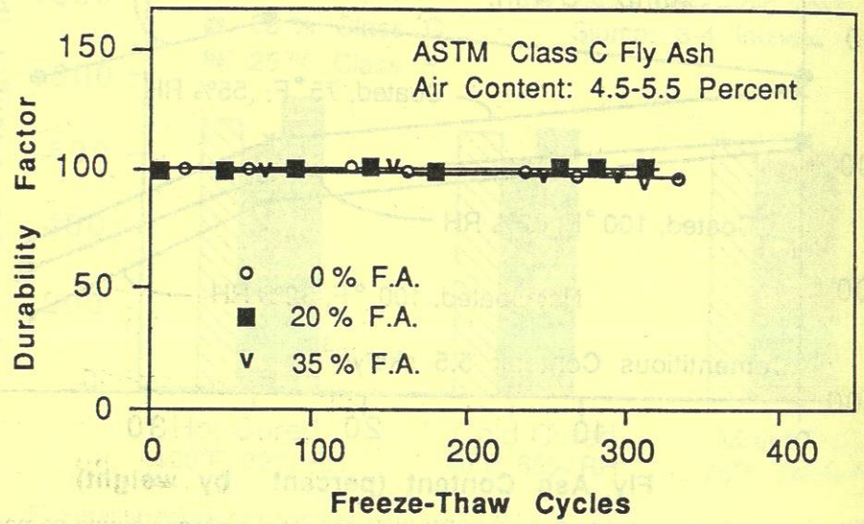


Fig. 9 Freeze-Thaw durability of concrete with fly ash.

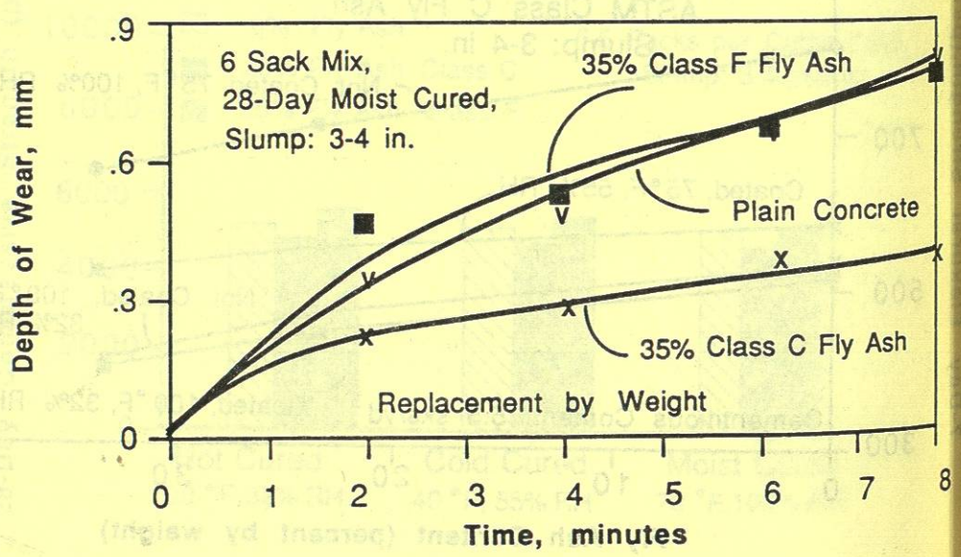


Fig. 10. Abrasion resistance of concrete containing fly as.

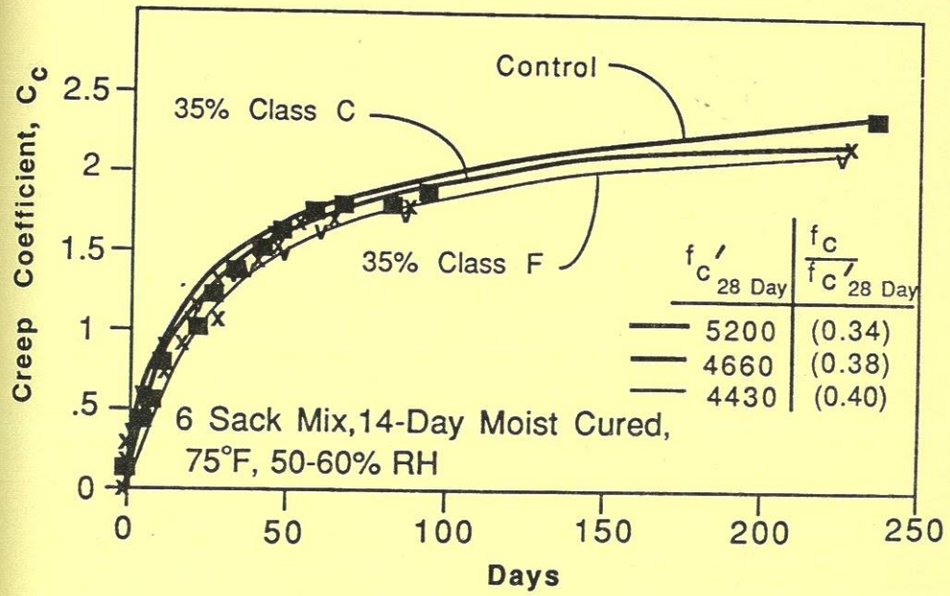


Fig. 11. Creep in concrete containing fly ash.

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