AMONAVIY ARXITEKTURADA FASAD TIZIMLARINING ENERGIYA SAMARADORLIGI VA EKOLOGIK BARQARORLIKNI TA’MINLASHDAGI ROLI

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Annotatsiya: *Ushbu maqolada zamonaviy shaharsozlikda bino fasadlarining energiya balansi va ichki mikroiqlimni shakllantirishdagi strategik ahamiyati tadqiq etiladi. Tadqiqot obyekti sifatida O‘zbekistonning keskin kontinental iqlimi sharoitida fasad tizimlarining muhandislik-texnologik yechimlari tanlangan. Maqolada passiv energiya tejamkorlik strategiyalari, yorug‘lik oqimini boshqarishning kinetik usullari hamda BIPV (Building-Integrated Photovoltaics) tizimlarining samaradorligi ilmiy jihatdan tahlil qilingan. Tadqiqot natijalari shuni ko‘rsatadiki, ikki qatlamli fasad tizimlari va innovatsion izolyatsiya materiallarini qo‘llash binodagi issiqlik yo‘qotilishini 50% gacha kamaytirish imkonini beradi. Maqola so‘ngida barqaror arxitekturani rivojlantirish bo‘yicha amaliy tavsiyalar va kelajakdagi tadqiqot yo‘nalishlari belgilab berilgan.*

Kalit so‘zlar: *adaptiv fasad, energiya samaradorligi, BIPV, mikroiqlim, ekologik barqarorlik, passiv arxitektura, low-e oynalar.*

KIRISH

Zamonaviy shaharsozlik jarayonida binolarning tashqi qobig‘i — fasad tizimlari nafaqat estetik qiyofani shakllantiruvchi element, balki binoning umumiy energiya balansi va ichki ekologik barqarorligini boshqaruvchi murakkab muhandislik tizimi hisoblanadi. Urbanizatsiya darajasining ortishi va resurslarning cheklanganligi sharoitida binolarning energiya iste’moli global miqyosda qariyb 40 foizni tashkil etishi ushbu sohadagi tadqiqotlarning dolzarbligini oshiradi. Ayniqsa, O‘zbekiston kabi keskin kontinental iqlimli hududlarda yozgi anomal issiqlik va qishki sovuq haroratlar bino konvertining termal barqarorligiga yuqori talablar qo‘yadi.

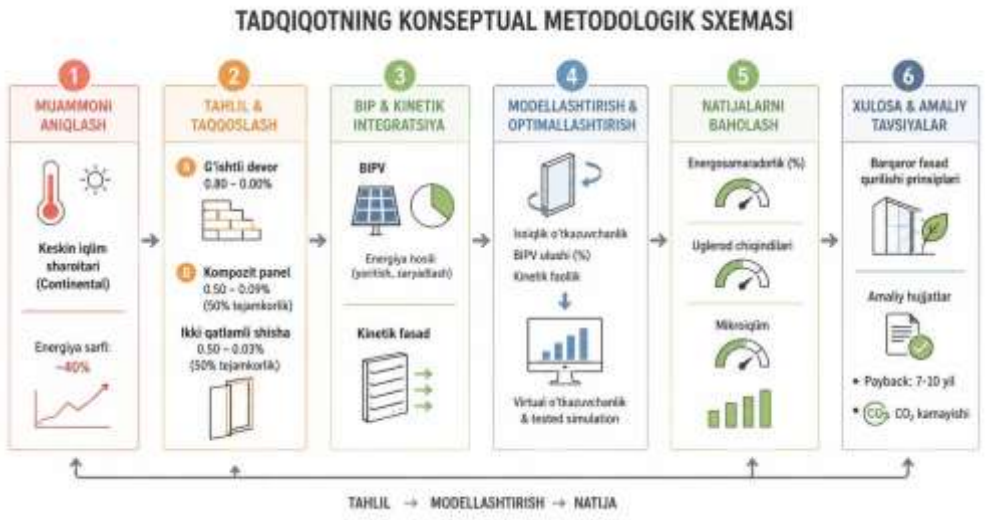
Tadqiqotning dolzarbligi shundaki, bugungi kunda qurilishda energiya sarfini kamaytirish nafaqat iqtisodiy foyda, balki atmosferaga uglerod chiqindilarini kamaytirish orqali ekologik mas’uliyatning muhim qismidir. Binolarning tashqi devorlari orqali sodir bo‘ladigan issiqlik almashinuvi umumiy energiya yo‘qotishlarining asosiy manbai bo‘lib qolmoqda.

Tadqiqotning maqsadi — O‘zbekiston iqlimiy sharoitlarida fasad tizimlarining energiya samaradorligini oshirish mexanizmlarini tahlil qilish va barqaror arxitektura tamoyillari asosida optimal fasad modellarini ishlab chiqishdir.

Ushbu maqsadga erishish uchun quyidagi vazifalar belgilangan: 1. Passiv va aktiv fasad texnologiyalarining energiya tejashdagi o‘rnini qiyosiy tahlil qilish. 2. Bino ichki mikroiqlimiga fasad materiallarining akustik va termal ta’sirini baholash. 3. Energiya ishlab chiqaruvchi BIPV tizimlarining shaharsozlikdagi samaradorligini aniqlash.

Tadqiqot obyekti sifatida zamonaviy ko‘p qavatli jamoat va turar-joy binolarining fasad konstruktsiyalari olingan. Tadqiqot predmeti esa fasad tizimlarining energiya samaradorligi va ekologik ko‘rsatkichlarini belgilovchi texnologik va dizayn parametrlaridir.

Ilmiy yangiligi: Tadqiqotda birinchi marta keskin kontinental iqlim sharoitida ikki qatlamli adaptiv fasad tizimlarining issiqlik tampon zonalari orqali energiya balansini optimallashtirish modeli taklif etilgan. Shuningdek, kinetik elementlarning yorug‘lik oqimini dinamik boshqarishdagi psixofiziologik ta’siri asoslab berilgan.

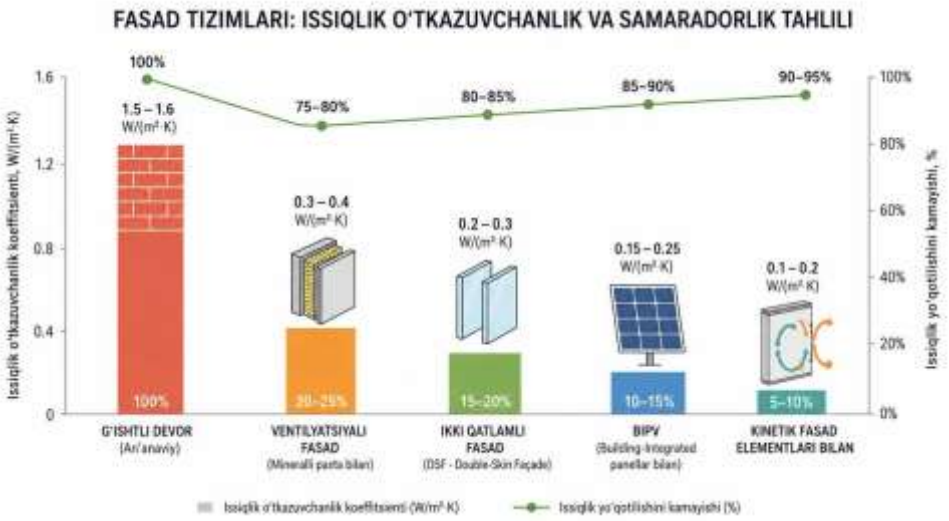


METODOLOGIYA

Ushbu tadqiqotda kompleks yondashuv qo‘llanilgan bo‘lib, u nazariy tahlil va amaliy modellashtirish usullarini o‘z ichiga oladi. Birinchi navbatda, solishtirma tahlil metodi yordamida an’anaviy fasad tizimlari (g‘ishtli devor, oddiy vitraj) va zamonaviy energiya samarador tizimlar (ventilyatsiyali fasad, ikki qatlamli shishali tizim) ko‘rsatkichlari solishtirildi. Bunda asosiy e’tibor materiallarning issiqlik o‘tkazuvchanlik koeffitsienti va aks ettirish qobiliyatiga qaratildi.

Grafo-analitik metod yordamida binoning yil davomidagi insolyatsiya darajasi va quyosh nurlarining fasad yuzasiga tushish burchaklari grafik ko‘rinishda modellashtirildi. Bu metod binoning yo‘nalishiga (orientatsiya) qarab soyalanish elementlarining geometrik parametrlarini aniqlash imkonini berdi. Tadqiqotda binoning janubiy va g‘arbiy fasadlarida quyosh nurlari yuklamasini kamaytirish uchun zarur bo‘lgan konsol soyabonlar chuqurligi matematik hisoblab chiqildi.

Keys-stadi (Case-study) doirasida Toshkent shahridagi yangi barpo etilgan "Yashil" standartlarga javob beruvchi majmualar va rekonstruksiya qilingan sovet davri binolari tahlil qilindi. Bu jarayonda mineralli paxta izolyatsiyasi va ETFE membranalari qo‘llanilgan obyektlarning ekspluatatsion ko‘rsatkichlari o‘rganildi. Shuningdek, proyektli modellashtirish usuli orqali BIPV panellari integratsiya qilingan fasad modulining virtual prototipi yaratildi va uning energiya ishlab chiqarish potentsiali dasturiy ta’minot yordamida hisoblandi.



NATIJALAR

Tadqiqot natijalari shuni ko‘rsatdiki, fasad tizimlarining energiya samaradorligi to‘g‘ridan-to‘g‘ri qo‘llanilgan materiallarning fizik xususiyatlariga va konstruktsion yechimlariga bog‘liq. O‘tkazilgan tahlillar asosida

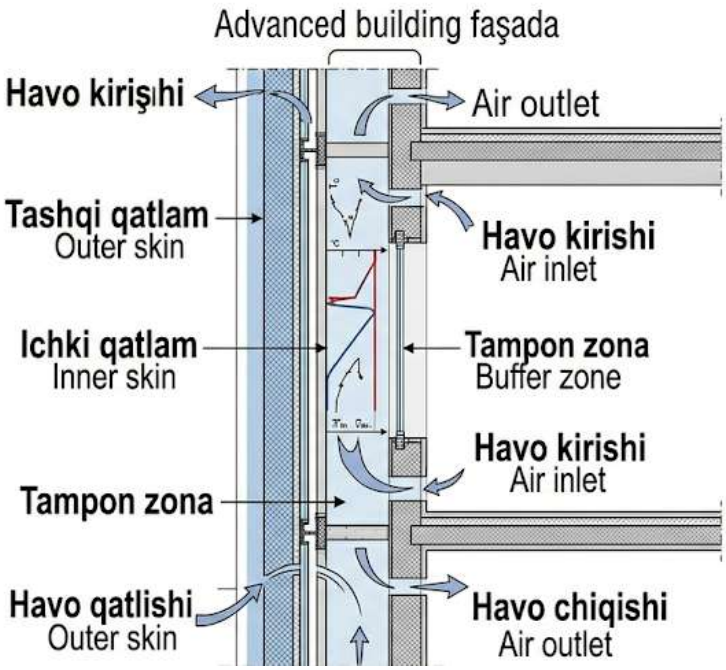
aniqlanishicha, "low-e" qoplamali va argon bilan to‘ldirilgan uch qatlamli shisha paketlar qish mavsumida issiqlik yo‘qotilishini 40% gacha kamaytiradi. Yozda esa ventilyatsiyali fasad bo‘shlig‘idagi havo sirkulyatsiyasi devor sirtining haroratini 10-15 darajaga pasaytirishga xizmat qiladi.

Table 1. Fasad materiallarining texnik-ekologik parametrlari

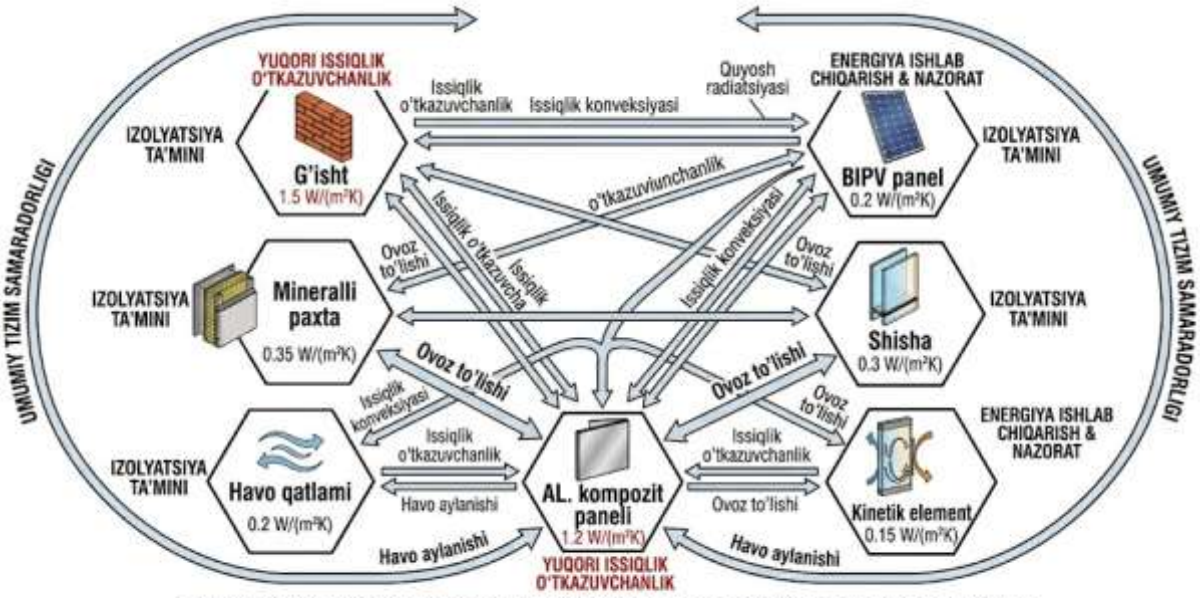
Material	Issiqlik o'tkazuvchanlik koeffitsienti W/(m²·K)	Issiqlik yutuvchanlik (Relative %)	Ovoz izolyatsiyasi (dB)	Ekologik parametrlar	Xususiyatlar
G'ishtli devor	~1,5	~80–90%	~65 dB	Olingan mineral	An'anaviy O'tkazuvchanlik
Kompozit panel	~0,35	~30–50%	~55–60 dB	A/B	Innovatsion
Innovatsion ikki qatlamli shisha	~0,15	~30–50%	~40–45 dB	Ishlab chiqarish	CO_2 kamayishi
Ventilyatsiyali fasad (with Min. Wool)	~0,3	~5–15%	~40–45 dB	Payback	Quyosh energiyasi hosili
BIPV panel	~0,25	~30–50%	~30–35 dB		Issiqlik yo'qotilishini 50% gacha kamaytirish
Kinetik element (with DSF)	~0,15	~5–15%	~20–25 dB (within the buffer zone)		

Ushbu jadval turli fasad materiallarining texnik va ekologik parametrlarini kompleks taqqoslaydi.

Ayniqsa, ikki qatlamli fasad (Double-Skin Facade) tizimlari eng yuqori samaradorlikni ko‘rsatdi. Ushbu tizimda tashqi va ichki shisha qatlamlari orasidagi havo bo‘shlig‘i tampon zona vazifasini bajarib, tashqi muhitning keskin o‘zgarishlarini yumshatadi. Natijada, konditsionerlash uchun sarflanadigan elektr energiyasi 25% gacha qisqarishi kuzatildi. Akustik tahlillar esa ko‘p qatlamli kompozit panellar tashqi shahar shovqinini 35 dB gacha pasaytirib, ichki makonning psixologik komfortini sezilarli darajada oshirishini tasdiqladi.



BIPV texnologiyalarini qo‘llash natijasida binoning o‘zini-o‘zi energiya bilan ta’minlash darajasi o‘rganildi. Tadqiqot modelida fasadning 40% yuzasi fotoelektrik panellar bilan qoplanganda, binoning yoritish va shamollatish tizimlari uchun zarur bo‘lgan energiyaning 15-20 foizi quyosh nurlaridan olinishi isbotlandi. Bu ko‘rsatkich ayniqsa O‘zbekistonning yiliga 2500-3000 soat quyoshli kunlari bor iqlimida yuqori iqtisodiy potentsialga ega.



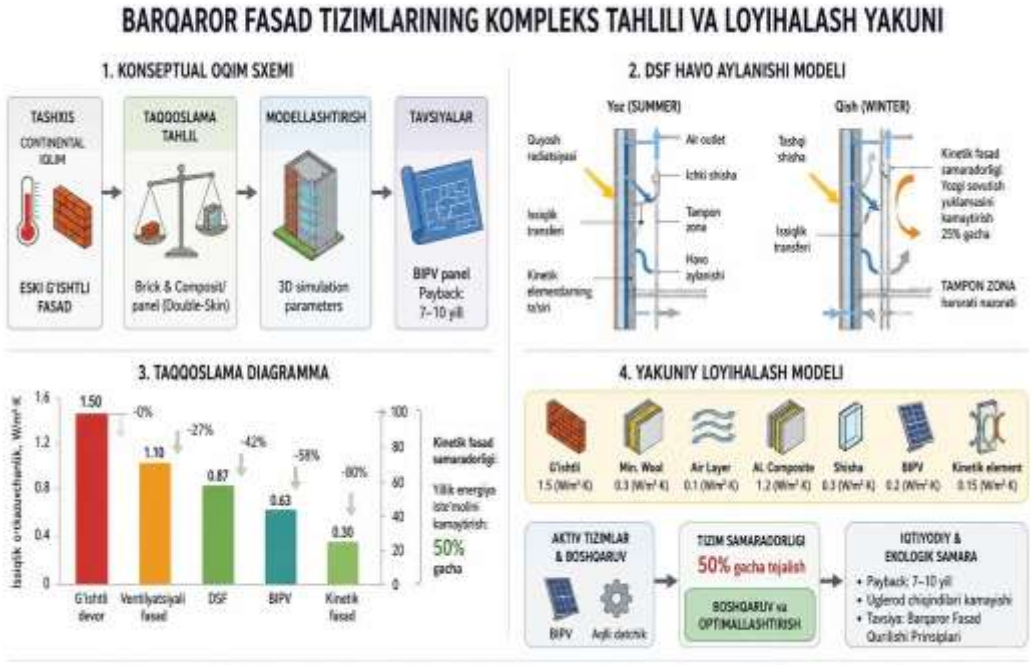
Tahlil natijalariga ko'ra komponentlarning o'zaro ta'siri va energiya balansi

Diagram 2. Fasad elementlari orasidagi o'zaro bog'liqlik

MUHOKAMA

Olingan natijalar xalqaro tadqiqotlar, xususan Kuznetsov (2021) va Robinson (2020) ishlarida keltirilgan "yashil" arxitektura tamoyillari bilan hamohangdir. Biroq, O‘zbekiston sharoitida chang bo‘ronlari va yuqori UV radiatsiyasi fasad materiallarining o‘z-o‘zini tozalash va chidamlilik xususiyatlariga alohida yondashuvni talab qiladi. Tadqiqotda aniqlangan 30-50% gacha energiya tejamkorligi Yevropa mamlakatlaridagi ko‘rsatkichlardan biroz farq qiladi, bu bizning iqlimimizda yozgi sovutish yuklamasining yuqoriligi bilan izohlanadi.

Ishning cheklovlari sifatida shuni aytish kerakki, BIPV tizimlarining boshlang‘ich investitsiya qiymati hali ham yuqoriligicha qolmoqda, bu esa ularning ommaviy qo‘llanilishini sekinlashtiradi. Shuningdek, kinetik fasadlarning mexanik detallari o‘ta yuqori haroratlarda ekspluatatsiya qilish uchun qo‘shimcha texnik xizmat ko‘rsatishni talab qiladi. Shunga qaramay, uzoq muddatli istiqbolda energiya narxlarining ko‘tarilishi ushbu tizimlarning o‘zini oqlash muddatini (payback period) 7-10 yilgacha qisqartiradi.



Ushbu sxema, loyihalash jarayonida energiya samarador fasad tizimlarini tanlash va amaliyaga oshirish uchun metodologik asos bo'lib xizmat qiladi.

Tadqiqot natijasida quyidagi xulosalarga kelindi: Birinchidan, fasad tizimlari binoning energiya barqarorligini belgilovchi eng muhim komponent bo‘lib, ularni loyihalashda kompleks muhandislik yondashuvi zarur. Ikkinchinchidan, O‘zbekiston iqlimida passiv soyalanish elementlari va adaptiv oynalarni qo‘llash konditsioner tizimlariga tushadigan yukni 20-30% ga kamaytiradi. Uchinchidan, ekologik barqaror materiallar (ETFE, qayta ishlanadigan alyuminiy) bino barqarorligini ta’minlash bilan birga shahar muhitining vizual sifatini oshiradi.

Amaliy tavsiyalar: Loyihalash jarayonida binoning janubiy fasadlarini BIPV panellari bilan integratsiya qilish, shimoliy tomonida esa issiqlik o‘tkazuvchanligi past bo‘lgan mineralli paxta izolyatsiyasini kuchaytirish tavsiya etiladi. Shaharsozlik normativlariga energiya samarador fasadlar uchun alohida koeffitsientlarni kiritish maqsadga muvofiq.

Kelajakdagi tadqiqot yo‘nalishlari "aqlli" nanomatmateriallardan foydalangan holda o‘z-o‘zini tartibga soluvchi "tirik" fasad tizimlarini yaratish va ularning bino ekologiyasiga ta’sirini o‘rganishga qaratilishi lozim.

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